International Journal of Social Science and Human Research

ISSN (print): 2644-0679, ISSN (online): 2644-0695

Volume 08, Issue 12 December 2025

DOI: 10.47191/ijsshr/v8-i12-95, Impact factor- 8.007

Page No: 9978-10005

The Neurobıologıcal Bases of Addıctıon and Psychologıcal Impulse Control Dısorders

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ABSTRACT: Addiction, a complex and chronic condition characterized by compulsive substance seeking and use despite adverse consequences, is underpinned by intricate neurobiological mechanisms. The neurobiological bases of addiction and psychological impulse control disorders can be largely attributed to synaptic plasticity, alterations in neurocircuitry, and dysregulation of reward pathways. The role of synaptic plasticity, particularly within the mesolimbic dopamine system, is prominent in the development and persistence of addictive behaviors. Drugs of abuse alter synaptic functioning, leading to persistent changes in neural circuits that drive craving and compulsive use behaviors.

Research indicates that exposure to addictive substances triggers a cascade of neurobiological adaptations primarily within the ventral tegmental area (VTA) and nucleus accumbens (NAc). These adaptations are characterized by changes in dopaminergic signaling and the recruitment of glutamatergic synapses, which significantly impact reward processing and impulse control. In particular, the dysregulation of the cortico-striatal pathways—a vital circuit for decision-making and behavioral control—contributes to impulsivity and compulsivity seen in addiction and related disorders. Furthermore, chronic drug use leads to an allostatic state, where the brain's reward system becomes less responsive to natural reinforcers, further compounding impulsive behaviors.

Neuroimaging studies have illuminated specific neural correlates of craving and cue reactivity in addiction. They reveal that drug-related stimuli elicit heightened activity in reward-related areas such as the NAc, often leading to conditioned responses that trigger relapse. This highlights the role of associative learning in addiction, where individuals develop strong memories linked to drug use that can unconsciously drive behavior long after cessation. The intersection of these neuroplastic changes with emotional and motivational states further complicates the impulse control disorders associated with addiction, reinforcing a cycle of use despite negative consequences.

To address the pervasive challenge of addiction, understanding the underlying neurobiological frameworks is essential. Novel treatment approaches are being explored that target these neuroplastic pathways to reverse maladaptive changes and restore balance within the neurocircuitry involved in addiction and impulse control. By elucidating the synaptic alterations and neuroadaptive mechanisms that underlie addictive behaviors, researchers hope to pave the way for more effective therapeutic interventions that not only target the symptoms of addiction but also fundamentally alter its trajectory.

In summary, the neurobiological bases of addiction and psychological impulse control disorders are deeply rooted in the principles of neuroplasticity, highlighting the intersection between learning, memory, and behavior. Future research should continue to unravel the complexities of these processes to innovate treatment strategies that enhance self-control and diminish the compulsive cycle of addiction.

KEYWORDS: Addiction, Neuroplasticity, Dopaminergic Signaling, Impulse Control Disorders, Reward System, Synaptic Plasticity, Mesolimbic System

1. INTRODUCTION

Addiction, a global public health issue, is one of the most complex and multi-layered problems of the modern age, requiring a biological and psychological holistic perspective. Today, addiction encompasses not only traditional substance use but also behavioral patterns such as technology, gambling, food, shopping, and relationship addiction, making it imperative to address the issue as a biopsychosocial syndrome.

Addiction and impulse control disorders involve closely related complex structures in terms of neurobiological mechanisms. The fundamental processes in these conditions are driven primarily by dopamine-based neural networks that regulate the brain's reward system. Neurobiologically, the reward-motivation circuit between the ventral tegmental area (VTA), nucleus accumbens, and

prefrontal cortex (PFC) forms the neurochemical basis of addictive behaviors. The artificial elevation of dopamine release in this system by addictive substances or behaviors initiates a chronic adaptation process by disabling the brain's natural reward mechanisms (Dubatova, I. and Antsyborov, A. (2019).

Psychologically, this situation develops within a cycle fueled by impulse control disorders, mood regulation difficulties, and learned reward-punishment relationships. Weakness in the prefrontal cortex's decision-making, self-control, and impulse control functions leads to the individual experiencing difficulty managing the conflict between short-term pleasure and long-term harm. This weakness provides a neuropsychological explanation for why addicted individuals continue their impulsive behaviors. At the same time, the amygdala and limbic systems play an active role in emotional interventions and sudden bursts of impulse that arise under stress (Laadraoui et al., 2025).

At the intersection of these biological and psychological processes, addiction is no longer merely an individual problem that can be explained by willpower. Genetic predisposition, brain chemistry, environmental stressors, and traumatic experiences shape this biopsychosocial syndrome. Therefore, addiction and impulse control disorders should be understood within the framework of common neurobiological currents and pathophysiological models.

The aim of this article is to present a conceptual framework to field experts and to propose a multifaceted model that will make clinical assessments and treatment interventions more effective by addressing the neurobiological foundations and psychological impulsive cycles of addiction and impulse control disorders within a scientific context.

2. Objective

This study aims to systematically investigate the neurobiological foundations of addictions and psychological impulse control disorders. Through a comprehensive review of various studies and articles in the literature, the goal is to identify which regions of the brain and neurochemical systems are associated with these disorders. Furthermore, determining the role of neuroplasticity and learning mechanisms in the development of these disorders and identifying neurobiological targets that can be reflected in clinical applications are among the primary priorities of this study. The aim of the study is to contribute to the understanding of the relevant neurobiological processes within a holistic framework in light of the existing information in the literature and to lay the foundation for new areas of research within this framework. In this regard, the examination of findings related to dopamine and glutamate-GABA balance and the relationship of these processes with impulse control disorders has been highlighted. Furthermore, the study aims to provide information for targeting neurobiological mechanisms while developing treatment approaches. Using a systematic review method, access to scientific literature was provided, and various study models and data were compiled. This aims to provide a clearer understanding of current developments in the neurobiology of addiction and impulse control disorders and their reflection in clinical practice. The comprehensive literature search and evaluation process aimed to approach the subject holistically and identify knowledge gaps in related fields. Thus, the study was supported by a database and methodological approaches that will contribute to the development of the field.

3. METHOD

In the methods section, the basic principles of a systematic review were observed. The literature to be used in the research was selected from studies that met the defined scope and inclusion criteria. In this context, priority was given to studies published in peer-reviewed journals within the last ten years and focusing on neurobiological foundations. The originality of the studies, their methodological rigor, and the timeliness of the results were taken into account. The search strategy utilized core databases such as PubMed, Scopus, Web of Science, and PsycINFO. The keywords “neurobiological basis,” “addiction,” “impulse control disorders,” “dopamine,” “prefrontal cortex,” and “brain functions” were identified. Searches using these keywords were compiled into a literature review category, and studies that were repetitive, off-topic, or methodologically inadequate were eliminated during the pre-selection phase. In data extraction, the main findings of the selected studies were systematically collected and comparative analyses were performed. In the synthesis phase, the commonalities and differences in the existing neurobiological data were evaluated in detail, and the role of addiction and impulse control disorders in brain mechanisms was clarified. The integrity and transparency of the methodological process ensured the reliability and reproducibility of the review. Furthermore, the peer-reviewed nature of the journals in which the selected studies were published and their compliance with ethical standards were taken into account. Thus, the data obtained formed a scientifically robust foundation and provided a solid resource that will contribute to the understanding of neurobiological underpinnings.

3.1. Scope and İnclusion Criteria

Scope and inclusion criteria play an important role in determining the scope of research in systematically reviewed studies. At this stage, scientific research in the field of neurobiological foundations of addictions and psychological impulse control disorders was considered. The inclusion criteria include studies that detail the relevant neurobiological mechanisms, present original data, and are methodologically sound. In addition, preference was given to articles published in recent times and in internationally recognized journals. These criteria ensured the reliability, validity, and thematic integrity of the studies. The language barrier for the studies was set as Turkish or English, and they were analyzed based on language proficiency. Furthermore, a wide range of studies were

selected, including empirical studies with clinical sampling, as well as experimental and observational models. In this way, a comprehensive literature review was conducted by integrating different approaches and results related to neurobiological foundations. Therefore, these limitations and criteria aim to contribute to the knowledge base in the field while maintaining the accuracy and integrity of the systematic review.

3.2. Databases and Search Strategies

During the literature review phase, a systematic approach was adopted to obtain original and reliable information. In this context, PubMed, Web of Science, Scopus, and PsycINFO were used as the main scientific databases. Each database was selected to cover research in the fields of neurobiology, psychiatry, and psychology. When determining search strategies, keywords and synonymous expressions were carefully identified and appropriate combinations were created. Keywords included "neurobiological foundations," "addiction," "impulse control disorders," "dopamine pathway," "prefrontal cortex," and "neuroplasticity." In addition to these terms, searches were optimized using Boolean operators (AND, OR, NOT). Furthermore, while the time frame was generally set to the last 10 years, some important studies from earlier periods were also included to access fundamental studies and classic research. During the screening process, article titles and abstracts were first reviewed, and studies deemed appropriate were accessed in full text for detailed evaluation. During the literature review, studies were selected based on specific qualitative and quantitative criteria, taking into account the methods used in the studies, sample groups, and key findings. These systematic search strategies are critical for ensuring the integrity of the literature and obtaining original and comprehensive information appropriate to the scope of the research. In addition, the reference lists of some studies were examined in detail and used as an additional source of information to access related new research. These approaches aim to provide a comprehensive and up-to-date perspective on the subject.

3.3. Evaluation and Data Extraction

During the evaluation and data extraction phase, the methodological quality of the studies obtained and the comparability of the results were prioritized. In line with the criteria used in the literature review, the studies were evaluated in terms of experimental design, sample size, measurement tools, and analysis techniques. High-quality data were selected, taking into account the validity and reliability levels of the studies. Furthermore, neurobiological measurement methods (such as fMRI, PET, EEG) used in different studies were classified in a consistent manner, and the results were systematically compared. During this process, various quality control criteria were applied to ensure the verifiability and reproducibility of the data. Additionally, the findings were checked for compliance with generally accepted standards, and potential biases and prejudices were minimized. During the data extraction phase, the collected information was synthesized through qualitative and quantitative analyses, and common themes and patterns were identified. In this context, the role of various neurobiological mechanisms in addiction and impulse control disorders was revealed, and data related to different regions of the brain and synaptic communication pathways were summarized through categorizations. As a result, in addition to a systematic evaluation, the meticulous application of the criteria used throughout the study ensured that the data obtained from the literature was analyzed in a comprehensive and reliable manner, forming the basis for the fundamental neurobiological mechanisms discussed in the following sections.

4. NEUROBIOLOGICAL BASES OF ADDICTION

4.1. Dopamine and the Brain's Reward System

4.1.1 The role of dopamine in the motivation–pleasure mechanism

Dopamine plays an important role in the brain's reward system, and its relationship with motivation-pleasure mechanisms is a critical element in understanding this system. Dopamine influences reward seeking and learning processes, particularly by interacting with structures such as the ventral tegmental area (VTA) and nucleus accumbens (NAc). Dopamine neurons in the VTA increase signals during the anticipation of a reward, thereby enhancing motivation and directing behavior accordingly (Zessen et al., 2021).

In addition to increasing motivation, dopamine also supports the pursuit of pleasure. The dopamine projection from the VTA to the NAc plays a critical role in identifying stimuli that are rewarding to the user and in reinforcing behaviors directed toward these stimuli. Thus, the learning and consolidation of behaviors that result in obtaining a specific reward are possible due to dopamine's effect in this cycle (Zessen et al., 2021; Fields et al., 2007). Furthermore, the timing of neuronal activity during learning processes plays an important role in shaping the motivational and reward-related effects of dopamine release (Fields et al., 2007).

All these interactions shape individuals' experiences of motivation and pleasure, and are therefore important in understanding and treating conditions such as addiction. A better understanding of dopamine mechanisms will be beneficial in developing new treatment strategies (Ebner et al., 2010).

Ultimately, dopamine's role in the motivation-pleasure mechanism is evident in its effects on the reward system. The effects of this neurotransmitter in the brain on behavioral motivation are critical in shaping individuals' reward seeking and learning processes.

4.1.2 Main structures of the reward circuit:

The brain's reward circuit is a complex network that regulates individuals' motivation, reward perception, and learning processes. This circuit primarily consists of three main structures: the Ventral Tegmental Area (VTA), the Nucleus Accumbens (NAc), and the

Prefrontal Cortex (PFC). These structures interact via dopaminergic neurons and play a critical role in directing individuals' reward seeking.

The Ventral Tegmental Area (VTA) is one of the fundamental building blocks of the brain's reward system and contains dopamine-producing neurons. Dopamine projections originating from the VTA extend to other important brain regions, including the NAc and PFC. These regions play a central role in processes related to reward and pleasure. Activation of the VTA typically has an effect that increases reward anticipation and motivation in individuals, helping them to sustain desired behaviors. The release of neurotransmitters, particularly dopamine, when a reward is obtained, makes those rewards a source of motivation (Stacey et al., 2012).

The Nucleus Accumbens (NAc) is a region that receives dopamine signals from the VTA and plays a critical role in processing motivational values. The NAc is sensitive to the effects of both natural rewards and addictive substances. Dopamine release enhances reward perception in the NAc, which strengthens individuals' reward-seeking behaviors. The NAc also contributes to reward prediction and the direction of behavioral responses by indirectly interacting with the PFC (Yaka & Khayat, 2023).

The Prefrontal Cortex (PFC), while linked to the reward system, plays a significant role in shaping decision-making and social behaviors. The PFC sends glutamatergic projections to the NAc and VTA, and this interaction contributes to complex processes that regulate an individual's behaviors. For example, dopamine levels in the PFC can influence individuals' motivation levels, shaping their perspectives on addiction and behavioral flexibility. The PFC's function acts as an important modulator in the process of achieving rewards by influencing the formation of reward-related thoughts (Abdel-Hay et al., 2024).

Consequently, the interactions between the VTA, NAc, and PFC determine the complexity and functionality of the brain's reward circuit. The collaborative functioning of these structures is of great importance for understanding the underlying neurobiological foundations of addictive behaviors, reward processing mechanisms, and motivational processes. The synaptic connections and dopamine release between the VTA, NAc, and PFC play a decisive role during individuals' reward-seeking behaviors and reveal the functioning of this critical circuit in the brain (Khayat & Yaka, 2024).

4.1.3 Desensitization of dopamine receptors in addiction

Dopaminergic pathways play a critical role in addiction, and evidence suggests that the desensitization of dopamine receptors, particularly D2, is an important underlying mechanism of this phenomenon. Desensitization typically involves a temporary decrease in receptor sensitivity as a result of prolonged exposure to agonists, leading to neurotransmission and behavioral changes indicative of addiction.

Studies show that internalization and desensitization of dopamine receptors such as D2 are influenced by the effect of G protein-coupled receptor kinases (GRKs). Burström and colleagues highlighted the regulatory mechanisms of the receptor by demonstrating that the onset of arrestin and subsequent desensitization of the D4 receptor are regulated by GRK2 (Burström et al., 2023). This activation of arrestin is a critical step that can affect the receptor's ability to signal efficiently after prolonged stimulation, a situation observed in addiction scenarios where repeated drug use leads to downregulation of the receptor (Burström et al., 2023).

The relationship between dopamine receptors and scaffold proteins such as spinophilin further illuminates the complexity of receptor dynamics and desensitization. Research indicates that spinophilin directly interacts with the D2 receptor and is concentrated in brain regions associated with reward and addiction, such as the striatum (Lin et al., 2001). Changes in synaptic structure associated with long-term drug use, such as downregulation of these proteins, may contribute to the long-term behavioral changes seen in addiction (Lin et al., 2001).

Neuropharmacological research has revealed that drugs such as amphetamine and cocaine can cause significant changes in the dopamine system and often lead to receptor changes following chronic exposure. These neuroadaptive processes occur in dopaminergic circuits in response to drug use. Wolstencroft et al. provided information on the endosomal cycle of dopamine receptors, which may contribute to the perception of altered receptor activity after chronic exposure (Wolstencroft et al., 2007).

Furthermore, alterations in dopamine receptor availability, particularly a decrease in D2 receptor binding, are frequently observed in various substance use disorders, including alcohol and opioid dependence. Volkow et al. have noted significant decreases in striatal D2 receptor availability in relation to the observed behaviors and neurophysiology of addiction. Such reductions are thought to be related to the rewarding properties of substances; here, lower receptor availability may lead to decreased sensitivity to natural rewards, thereby reinforcing addictive behaviors (Volkow et al., 1996).

Consequently, dopamine receptor desensitization is a crucial element in the neural circuits of addiction. Understanding the molecular interactions between dopamine receptors, kinases, and associated proteins provides valuable insights for targeting interventions in addiction treatment.

4.1.4. Loss of Value of Natural Rewards

Dopamine is an important neurotransmitter in the brain, particularly in relation to reward behavior. Natural rewards, such as food and social interaction, promote dopamine release, providing pleasure and motivation. However, substance addiction can diminish the value of these natural rewards, reducing individuals' interest in them. Drug use excessively activates dopamine pathways, overshadowing the dopamine release provided by natural rewards (Tan et al., 2023).

During the process of drug addiction, dopamine levels in the mesolimbic system reach extraordinarily high levels compared to natural rewards. This leads individuals to develop an addiction to the substance and become insensitive to natural rewards. Tan et al. stated in their studies that individuals in the addiction process may transform their search for the substance into sacrificing natural rewards (Tan et al., 2023). As a result, individuals experience a decreased motivation toward natural rewards that are satisfying in daily life.

The functioning of natural reward mechanisms is closely related to the role of dopamine; however, addiction disrupts this mechanism by manipulating the dopamine system. Academic research shows that the diminished response of individuals with addiction to natural rewards is a cumulative result of effects on the brain's reward system (Parnaudeau et al., 2014). This creates a complex cycle that leads to an increase in individuals' dependence on the substance. Therefore, the loss of value of natural rewards can lead to a significant decline in individuals' quality of life.

In conclusion, addiction causes natural rewards to lose their value by affecting the dopamine system. This process, along with the progression of addiction, causes individuals to turn to more substances and thus move away from natural rewards.

4.2. Genetic Predisposition and Hereditary Risk

4.2.1 Addiction genes such as DRD2 and OPRM1

Addiction is a complex disease resulting from the interaction of genetic and environmental factors. Genetic makeup can significantly influence how individuals respond to addiction. Specifically, the DRD2 (dopamine D2 receptor gene) and OPRM1 (mu-opioid receptor gene) genes are among the important genes associated with addiction.

The DRD2 gene plays a critical role in the production of dopamine receptors and modulates the function of the dopamine system. The presence of the TaqI A1 allele indicates that individuals may be more susceptible to substances that cause addiction. Research has shown that variants of the DRD2 gene are a genetic risk factor in the development of addiction.

Mutations observed in the DRD2 gene have been shown to lead to a decrease in the number and effectiveness of dopamine receptors, which in turn increases the tendency for addiction in individuals (Jordan & Xi, 2022). Similarly, the OPRM1 gene plays an important role in regulating the effects of opioids.

The A118G (Asn40Asp) polymorphism in OPRM1 can increase addiction potential by affecting individuals' levels of interaction with beta-endorphin. Research has shown that this gene variant may have strong effects, particularly on opioid addiction, and may lead to differences in the dopaminergic reward mechanisms of addicted individuals. Variants in the OPRM1 gene have been found to be closely associated with addictive behaviors (Zhang et al., 2005).

The effects of these variations in genetic makeup in addiction play a decisive role in individuals' neurological response mechanisms and, consequently, addictive behaviors. While the DRD2 and OPRM1 genes are among the primary genetic factors predisposing individuals to addiction, it is also important to understand the effects of environmental factors on addiction, in addition to individuals' genetic profiles. In general, genetic variations and their consequences are a critical factor in determining individuals' susceptibility to addiction.

4.2.2 Familial Predisposition And Twin Studies

Addiction is a condition resulting from the interaction of hereditary and environmental factors, and twin and family studies are important for understanding the effects of these factors on individuals. Data obtained from such studies can help determine the genetic basis of addiction disorders and familial susceptibility.

In family studies, addiction disorders often occur at a high rate among family members. For example, a study by Levran et al. examined the effects of genetic factors related to opioid addiction and showed that the A118G variant (rs1799971) of the OPRM1 gene increases the risk of addiction (Levran et al., 2008). Such genetic variables may contribute to the prevalence of addictive behaviors, particularly among individuals with a specific family history.

Twin studies are also very useful for evaluating the effects of genetic and environmental factors on addiction. In a study by Roussotte et al., findings were presented indicating that low expression levels of the DRD2 gene increase the risk of addiction in individuals (Roussotte et al., 2014). Twins, due to their genetic similarity, provide the opportunity to examine the effect of genetic factors on addictive behaviors separately. Twin studies provide important information for disentangling the effects of specific genes on addiction and help calculate the percentage of influence of genetic factors.

A meta-analysis by Schwantes-An et al. revealed that the OPRM1 gene variant rs1799971 provides a shared genetic predisposition across different types of addiction and that this is associated with high genetic correlation across various types of addiction (Schwantes-An et al., 2015). This study provides strong evidence on how specific genetic variants can increase an individual's risk of developing addiction.

The effects of genetic and familial factors on addiction are better understood through twin and family studies. Genes such as OPRM1 and DRD2 play an important role in determining hereditary risks for addiction, and such studies may help identify genetic targets for the prevention and treatment of addiction disorders.

4.2.3. Epigenetic Changes (Environmental Stress + Gene Expression)

Epigenetic Changes Related to Addiction: Environmental Stress and Gene Expression

Epigenetics encompasses biological processes that alter gene expression without changing the DNA sequence. In the context of addiction, the effects of environmental stress on gene expression play an important role. In particular, there are important findings regarding how exposure to addictive substances affects individuals' gene expression through epigenetic changes.

A study by Ponomarev et al. investigated the epigenetic changes seen in the brains of individuals with alcohol addiction. This study indicated that alcohol and cocaine decrease histone deacetylase (HDAC) activity, which leads to increased regulation of the MBD3 gene in individuals with alcohol dependence. Furthermore, an increase in HDAC activity was observed with alcohol withdrawal and chronic cocaine use (Ponomarev et al., 2012).

Browne and colleagues examined the relationship between opioid addiction and epigenetic mechanisms. Their investigations highlighted that MOR agonists and semi-agonists used in the treatment of opioid addiction cause epigenetic changes and emphasized the importance of these changes on addiction.

Furthermore, preliminary studies in male mice have demonstrated the need to understand sex differences to broaden the scope of opioid-induced epigenetic changes (Browne et al., 2020). Epigenetic changes also involve interactions with stress and gene expression.

A review by Maze and Nestler addressed the important role of epigenetic regulation in addiction. Stress can direct gene expression through histone modifications, and this, combined with additional addiction mechanisms, can profoundly affect individuals' addictive behaviors (Maze & Nestler, 2012).

A study by Do and colleagues examined epigenetic mechanisms and the effects of stress in opioid addiction. In particular, it was noted that epigenetic changes caused by environmental stress factors have lasting effects on synaptic plasticity, making individuals more susceptible to opiate addiction (Do, 2024). In this context, it has been autonomously demonstrated that developmental difficulties and substance exposure during adolescence create permanent epigenetic changes and that individuals carry a higher risk of addiction in their later lives.

In this context, addiction-related epigenetic changes arise from a complex interaction between environmental stress and gene expression, and this situation can create sensitivity in individuals to addictive substances. Universally, the identification of these mechanisms offers important opportunities for both treatment strategies and the prevention of addiction.

4.2.4 Post-traumatic genetic activation models

Post-traumatic stress is an important factor that increases the risk of developing addiction. Conditions such as psychosis or addiction are more common in individuals who have been exposed to traumatic events. Various studies have investigated the epigenetic changes that environmental stress and trauma cause in gene expression.

Szklarczyk and colleagues examined post-traumatic stress responses in four different inbred mouse strains. Their work revealed a link between increased Fkbp5 gene expression and post-traumatic avoidance behavior observed in the DBA/2J mouse strain Szklarczyk et al. (2012). Furthermore, increased levels of the Crhr1 gene in C57BL/6J mice were found to be associated with stress and anxiety.

The effects of trauma are quite complex, especially in terms of psychiatric disorders. A study by Liu and colleagues identified specific genes and pathways for post-traumatic stress disorder (PTSD). Among the genes examined were those associated with cigarette addiction, and it was found that this condition intensified the psychological effects of trauma (Liu et al., 2025).

In addition, Iqbal and colleagues examined the effects of a single prolonged stressor on the medial prefrontal cortex and the resulting increase in anxiety-like behaviors. It was found that the effects of stress developed in parallel with the gene expression changes it caused in brain regions (Iqbal et al., 2024). Such changes shed light on the neurological and behavioral consequences of traumatic stress.

Blacker and colleagues reviewed the epigenetic changes associated with PTSD.

The role of genetic and epigenetic factors in the development of PTSD has been emphasized, as they may influence individuals' susceptibility to this disorder and its clinical symptoms (Blacker et al., 2019). In this context, the effects of gene expression changes on addiction, in conjunction with environmental stress, should be considered.

Consequently, the effects of post-traumatic stress on addiction are determined by an interaction of genetic and epigenetic mechanisms. Studies reveal that genetic and environmental factors play a decisive role in increasing the risk of developing addiction in individuals exposed to trauma. Therefore, a better understanding of the effects of stress and trauma on addiction is important for developing preventive strategies and improving treatment approaches.

4.3. Neuroplasticity and Brain Adaptations

4.3.1. Synaptic strengthening/weakening

Neuroplasticity, particularly in the contexts of long-term potentiation (LTP) and long-term depression (LTD), plays a crucial role in how the brain adapts to repeated drug exposure, especially in addiction. These processes are essential for synaptic strengthening and weakening, which are key mechanisms in memory formation and the modulation of behavioral responses to stimuli. The complexities of these adaptations are especially evident in the mesolimbic dopamine system, including areas such as the nucleus accumbens (NAc) and the ventral tegmental area (VTA) (Fourgeaud et al., 2004).

Research has demonstrated that drugs of abuse, including cocaine and opioids, significantly alter synaptic plasticity within these regions. For example, repeated cocaine exposure has been shown to facilitate the induction of LTP while concurrently inhibiting LTD, leading to an enhancement of synaptic strength at glutamatergic synapses (Liu et al., 2005). Specifically, cocaine self-administration abolishes endocannabinoid-mediated LTD in the NAc, which alters neurotransmitter release and synaptic transmission, ultimately impacting reward processing and contributing to addiction-like behaviors (Fourgeaud et al., 2004). In terms of LTD, drugs of abuse can recruit mechanisms that typically promote adaptive changes, thus reinforcing maladaptive responses to environmental cues associated with drug use (Moussawi et al., 2009; Ruan & Yao, 2016; .Ruan & Yao, 2016).

The modulation of synaptic strength through LTP and LTD is critical not only in response to drugs but also in healthy cognitive functions such as learning and memory. This illustrates the dual role of these processes in both cognitive pathology and normal brain function. The alteration of LTP and LTD in addiction pathways emphasizes that compulsive substance use may stem from a disruption of normal neuroadaptive processes. The balance between excitatory and inhibitory synaptic transmission is compromised, which reinforces maladaptive behaviors associated with addiction (Liu et al., 2005).

Moreover, evidence suggests that the facilitation of LTP following repeated drug exposure can lower the thresholds for associative learning, meaning that drug-associated cues can more effectively evoke responses than natural reinforcers (Ruan & Yao, 2016). These findings illustrate that neuroplastic changes underpin the progression from casual substance use to addiction, driven by persistent alterations in synaptic function and signaling pathways—processes that render the brain's reward circuitry more plastic, thus supporting addiction.

In conclusion, neuroplasticity in the contexts of synaptic strengthening and weakening is central to addiction processes, with LTP and LTD serving as critical mechanisms that can either foster healthy adaptations or contribute to addictive behaviors through maladaptive changes in synaptic transmission.

4.3.2. Long-term potentiation (LTP) and addiction relationship

Long-term potentiation (LTP) is a critical form of synaptic plasticity characterized by the long-lasting enhancement of synaptic transmission following high-frequency stimulation. This mechanism is fundamental not only for learning and memory but also for the maladaptive changes associated with drug addiction. The relationship between LTP and addiction is primarily manifested through alterations in the mesolimbic dopamine system, particularly involving structures like the nucleus accumbens (NAc) and the ventral tegmental area (VTA).

Drugs of abuse, such as cocaine and heroin, have been shown to induce LTP in various brain regions integral to reward and motivation. For example, research indicates that cocaine administration promotes an increase in synaptic strength within the VTA, which is believed to enhance the incentive motivational properties associated with the drug (Dong et al., 2004). This heightened synaptic response correlates with the development of compulsive drug-seeking behaviors and an increased sensitivity to drug cues—a process known as behavioral sensitization. Essentially, LTP enhances the plasticity of these reward pathways, making them more responsive to cues associated with drug use, which may contribute to the cycle of addiction (Dong et al., 2004).

Moreover, the chronic presence of addictive substances can modify the homeostatic balance of LTP and long-term depression (LTD), often leading to a dysfunction where the typical adaptive synaptic responses are replaced by maladaptive plasticity (Moussawi et al., 2009). For example, studies have shown that cocaine can disrupt normal LTD in the VTA, resulting in a persistent state of hyperexcitability and reinforcing behaviors associated with drug use (Moussawi et al., 2009) . This disruption can lead to a form of metaplasticity, where the capacity for synaptic enhancement becomes compromised, making it difficult for individuals to alter their drug-seeking behavior despite negative consequences (Moussawi et al., 2009).

Another critical aspect of addiction-related LTP involves its implications for memory formation and behavioral conditioning. The enhancement of LTP processes in addiction models corresponds with the formation of drug-associated memories, which can become powerful motivators for continued drug use. This is further evidenced by findings demonstrating how synaptic modifications in the NAc facilitate the recall of drug-related cues, thus perpetuating the cycle of craving and consumption (Tang & Dani, 2009). These effects underscore the idea that addiction may represent an aberrant form of learning and memory, where drug-induced enhancement of synaptic strength alters the functioning of neural circuits responsible for reward processing and decision-making (Tang & Dani, 2009).

In summary, LTP plays a pivotal role in the neurobiological adaptations seen in addiction. By facilitating enhanced synaptic strength and maladaptive memory processes, LTP contributes to the persistence of addictive behaviors and the challenges associated with achieving sustained recovery from substance use disorders.

4.3.3. The effect of chronic substance use on gray matter volume

Chronic substance use significantly impacts gray matter volume in various critical brain regions, particularly those associated with addiction, reward processing, and cognitive functions. Substantial evidence demonstrates that prolonged exposure to addictive substances can lead to persistent reductions in gray matter, which are closely linked to behavioral impairments commonly observed in individuals with substance use disorders.

One pertinent study found that individuals with a history of cocaine dependence exhibited marked reductions in gray matter volume in areas such as the prefrontal cortex and the insula. These areas play essential roles in executive function, impulse control, and

decision-making. The alterations in gray matter volume were shown to correlate with deficits in these cognitive processes, which are vital for maintaining self-control over drug-seeking behaviors Knackstedt et al. (2010)Chen et al., 2008). Such cognitive impairments are believed to result from the neurotoxic effects of chronic drug use, further perpetuating the cycle of addiction.

Additionally, another study highlighted similar effects in methamphetamine users, revealing significant gray matter atrophy in the frontal and temporal cortices, as well as the nucleus accumbens and ventral tegmental area (VTA) (Moussawi et al., 2009). The loss of gray matter in these areas is associated with disruptions in dopamine signaling and emotional regulation, which are often compromised in individuals suffering from addiction (Mazei-Robison et al., 2011).

Moreover, longitudinal studies suggest that the recovery of gray matter volume may occur following prolonged abstinence, indicating potential neuroplasticity and the brain's capacity for regeneration. However, the degree and rate of recovery are often variable and may depend on the type of substance used, duration of use, and individual differences in neurobiology. For instance, a return to baseline levels of gray matter volume has been documented in some regions of the brain, supporting the notion that with sustained abstinence, some neuroadaptive processes can partially reverse effects induced by chronic substance exposure (Marusak et al., 2017).

In summary, chronic substance use induces significant changes in gray matter volume in critical regions of the brain associated with addiction and cognitive function. These changes highlight the neurobiological underpinnings of addiction and contribute to the understanding of how long-term substance use can result in enduring cognitive deficits.

4.3.4. Restructuring of reward system circuits

The rewiring of reward circuitry is a fundamental aspect of neuroplasticity in addiction, a process wherein chronic substance use modifies the brain's reward pathways, particularly the mesolimbic dopamine system. These adaptations can lead to altered neural responses to both natural rewards and drug-related stimuli, ultimately contributing to the compulsive behaviors characteristic of addiction.

Addictive substances induce structural and functional changes in the brain's reward circuitry. For example, Kelley and Berridge posited that repeated exposure to addictive drugs sensitizes the mesocorticolimbic system to incentive salience, which is the "wanting" aspect of rewards. This sensitization leads to a distorted reward processing mechanism where drug cues become disproportionately appealing compared to natural rewards, resulting in increased craving and compulsive drug-seeking behavior (Kelley & Berridge, 2002)

Moreover, dysregulation of the reward system due to chronic substance use is evidenced by shifts in the balance of synaptic signaling in areas such as the ventral tegmental area (VTA) and the nucleus accumbens (NAc). Drugs of abuse promote long-term potentiation (LTP) within these regions, as seen in studies showing that repeated cocaine exposure enhances the induction of LTP at excitatory synapses on dopamine neurons (Liu et al., 2005). This potentiation reinforces drug associations and enhances the motivation to pursue drugs, thereby reshaping the individual's reward-based decision-making processes.

The consequences of these neural adaptations extend to impulse control and emotional regulation, areas that are critically dependent on the integrity of the prefrontal cortex and its connections to reward circuitry. Impairments in these functions, often exacerbated by substance use, lead to a diminished capacity for individuals to respond to natural reinforcers effectively, further consolidating the behavioral patterns associated with addiction (Kelley & Berridge, 2002).

In summary, chronic substance use leads to substantial rewiring of the brain's reward circuitry, characterized by enhanced LTP and altered incentive salience. These neuroplastic changes underpin the persistent change in motivation and behavior in addiction, highlighting the challenges faced in recovery and the potential for further research into therapeutic interventions.

4.4. Stress Hormone (Cortisol) and Addiction

4.4.1 Stress triggering dopamine release

Chronic stress significantly influences the neurobiological mechanisms underlying addiction, particularly through its effects on the hypothalamic-pituitary-adrenal (HPA) axis, which regulates the release of cortisol. Cortisol, known as the stress hormone, plays a crucial role in modulating both physiological and behavioral responses to stress and has been implicated in the modulation of dopamine release, central to addiction processes.

Research indicates that stressful experiences can trigger an increase in dopamine release in the brain's reward circuitry, especially in the mesolimbic pathway, which includes regions such as the ventral tegmental area (VTA) and the nucleus accumbens (NAc) (Bearn et al., 2001). This release of dopamine contributes to the brain's reward response to both natural reinforcers and substances of abuse. For example, cortisol has been found to potentiate the effects of opiates, suggesting that stress influences mood and cognition and enhances the rewarding effects of addictive substances, reinforcing drug-seeking behavior (Bearn et al., 2001).

Moreover, there is compelling evidence that the activation of the HPA axis during stress episodes may promote cravings and increase the likelihood of substance use. Elevated cortisol levels resulting from stress correlate with increased drug-seeking behaviors and cravings in individuals recovering from addiction (Cleck & Blendy, 2008). This relationship highlights how stress can override homeostatic controls, leading to maladaptive behaviors associated with addiction.

Furthermore, individuals with histories of substance abuse often exhibit altered cortisol reactivity in response to stress, predisposing them to relapse or increased drug-seeking behaviors. Studies indicate that addicts may display heightened cortisol responses when exposed to drug-related cues, triggering dopamine release and leading to cravings, effectively linking stress experiences to immediate increases in substance-seeking behavior (Wand et al., 2007).

In conclusion, the intricate relationship between stress, cortisol release, and dopamine signaling presents a substantial mechanism through which stress triggers addiction-related behavior. The modulation of dopamine release by cortisol under stressful conditions illustrates the complex neurobiology of addiction and points to potential therapeutic avenues for managing stress-related substance use disorders.

4.4.2. The "stress-addiction" cycle

The relationship between stress and addiction is characterized by a cyclical interaction where stress triggers substance use, and substance use, in turn, exacerbates stress levels. Central to this cycle is cortisol, the primary stress hormone, which plays a crucial role in the body's response to stress and subsequent addictive behaviors.

In moments of stress, the hypothalamic-pituitary-adrenal (HPA) axis is activated, leading to an increase in cortisol levels. Elevated cortisol plays a dual role in addiction; while it helps the body cope with stress, its chronic heightened levels can lead to alterations in brain function and behavior that predispose individuals to substance use. Research by Daughters et al. highlights how heightened cortisol responses to stress are associated with difficulties in treatment retention for individuals in residential substance abuse programs, suggesting that typical stress responses can be maladaptive for individuals struggling with addiction Daughters et al. (2009).

Moreover, studies demonstrate that individuals with histories of substance dependence often exhibit blunted cortisol responses to stress (Buchanan et al., 2020). This diminished reactivity may reflect a physiological adaptation to chronic drug use, potentially lowering the threshold for stress-induced cravings and relapse. For instance, Lee et al. found significant correlations between stress and addictive behaviors, underscoring a bidirectional relationship where elevated stress levels lead to increased cravings and substance use, while substance dependence results in an impaired ability to cope with stress. This association between stress and addiction implies that stress can contribute to the development of addictive behaviors and vice versa (McMullin et al., 2020).

Furthermore, stress-induced cravings can trigger dopamine release, intensifying the cycle of addiction. The interaction between high cortisol levels and dopamine signaling reinforces the connection between stress and substance use, as elevated cortisol can enhance the brain's reward responses, increasing the motivation to seek substances that may temporarily alleviate the psychological discomfort arising from stress (eLi et al., 2014).

The stress-addiction cycle emphasizes the importance of understanding how stress responses can influence addictive behaviors and how addiction can, in turn, perpetuate stress. This cyclical nature underlines the complexity of treating addiction, as addressing underlying stressors and restoring healthy cortisol responses may be crucial in breaking the cycle and supporting recovery (Glahn et al., 2013).

4.4.3 Increased risk of addiction due to early-life trauma

The impact of early-life trauma on the propensity for addiction is intricately linked to the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and the subsequent alteration of cortisol levels in response to stress. Childhood adversities, such as physical or sexual abuse, profoundly affect the neurobiological systems that regulate stress and reward, thereby increasing susceptibility to substance use disorders later in life.

Research has demonstrated that individuals who have experienced early-life trauma exhibit alterations in cortisol responses that may predispose them to addiction. (Cleck & Blendy, 2008) highlight that chronic stress can amplify the rewarding effects of drugs, indicating that physiological changes triggered by stress hormones, such as cortisol, can heighten cravings and reinforce substance-seeking behaviors, forming a cycle of addiction (Cleck & Blendy, 2008).

Moreover, studies on HPA axis dysregulation have shown that trauma exposure can lead to an attenuated cortisol response to stress in later life, potentially impairing an individual's ability to cope with subsequent stressors. (Kuhlman et al., 2015) found that the age of trauma onset influences cortisol levels, with those exposed to trauma later in childhood exhibiting dysregulated cortisol patterns that correlate with heightened stress sensitivity and vulnerability to addiction (Kuhlman et al., 2015). This underscores the concept that early-life stress not only affects immediate physiological responses but also instigates long-term changes in the HPA axis regulation.

Cortisol's role in addiction is further elucidated by its interactions with the brain's reward system. Stress-induced elevations of cortisol can significantly alter dopamine signaling, as the release of this neurotransmitter within the mesolimbic pathway is increased under stress, thus reinforcing the rewarding properties of drugs (Bisagno & Cadet, 2014). Therefore, individuals with a history of early-life trauma may engage in enhanced drug-seeking behaviors as a maladaptive strategy to manage stress and arousal stemming from both psychological distress and physiological responses.

Furthermore, chronic exposure to high cortisol levels associated with sustained stress can lead to structural and functional alterations in the brain, amplifying vulnerability to addiction. (Schalinski et al., 2015) indicate that such changes are associated

with a decreased capacity for self-regulation and an increased likelihood of substance use as a means of self-medication against a backdrop of heightened stress and anxiety (Schalinski et al., 2015).

In summary, early-life trauma significantly impacts the HPA axis and cortisol levels, creating an environment that predisposes individuals to addiction. The interplay between stress hormones and the brain's reward circuitry fosters a cycle in which stress can trigger addiction, and addiction-related behaviors may, in turn, exacerbate stress, highlighting the complex interactions that underlie vulnerability to substance use disorders.

4.4.4. Dysfunction in the HPA axis

Chronic substance use significantly impacts gray matter volume in various critical brain regions, particularly those associated with addiction, reward processing, and cognitive functions. Substantial evidence demonstrates that prolonged exposure to addictive substances can lead to persistent reductions in gray matter, which are closely linked to behavioral impairments commonly observed in individuals with substance use disorders.

One pertinent study found that individuals with a history of cocaine dependence exhibited marked reductions in gray matter volume in areas such as the prefrontal cortex and the insula. These areas play essential roles in executive function, impulse control, and decision-making. The alterations in gray matter volume were shown to correlate with deficits in these cognitive processes, which are vital for maintaining self-control over drug-seeking behaviors Knackstedt et al. (2010). Such cognitive impairments are believed to result from the neurotoxic effects of chronic drug use, further perpetuating the cycle of addiction.

Additionally, another study highlighted similar effects in methamphetamine users, revealing significant gray matter atrophy in the frontal and temporal cortices, as well as the nucleus accumbens and ventral tegmental area (VTA) (Moussawi et al., 2009). The loss of gray matter in these areas is associated with disruptions in dopamine signaling and emotional regulation, which are often compromised in individuals suffering from addiction

Moreover, longitudinal studies suggest that the recovery of gray matter volume may occur following prolonged abstinence, indicating potential neuroplasticity and the brain's capacity for regeneration. However, the degree and rate of recovery are often variable and may depend on the type of substance used, duration of use, and individual differences in neurobiology. For instance, a return to baseline levels of gray matter volume has been documented in some regions of the brain, supporting the notion that with sustained abstinence, some neuroadaptive processes can partially reverse effects induced by chronic substance exposure (Marusak et al., 2017).

In summary, chronic substance use induces significant changes in gray matter volume in critical regions of the brain associated with addiction and cognitive function. These changes highlight the neurobiological underpinnings of addiction and contribute to the understanding of how long-term substance use can result in enduring cognitive deficits.

5. PSYCHOLOGİCAL İMPULSE CONTROL DİSORDERS

Psychological impulse control disorders (ICDs) encompass a range of conditions characterized by an inability to resist impulses, which can lead to maladaptive behaviors and significant distress. These disorders, including kleptomania, pyromania, and intermittent explosive disorder, often co-occur with other psychiatric illnesses and are commonly linked to disturbances in emotional regulation and executive functions. Such disorders can have profound effects on individuals' social functioning and mental health, necessitating comprehensive understanding and targeted interventions.

5.1. The Cycle of Addiction and Behavioral Mechanism

5.1.1. Trigger → Craving → Behavior → Temporary relief → Guilt → Repeat

The cycle of addiction operates as a repetitive sequence that perpetuates compulsive behaviors surrounding substance use and other maladaptive actions. This cycle begins with a trigger, which can be environmental cues, emotional states, or stressors that evoke cravings for the substance or behavior. As these triggers present themselves, they can lead to intense craving, characterized by an overwhelming desire to engage with the substance or behavior as a means of escape or relief Tomasi et al. (2014).

Once craving intensifies, individuals often engage in behavior, which refers to the act of using the substance or engaging in the addictive behavior. This action is frequently driven by the need to alleviate distress or anxiety linked to the trigger and craving. The outcome of this behavior typically provides temporary relief from negative emotions, reinforcing the cycle as the immediate effects of substance use can lead to feelings of pleasure and reward through the release of neurotransmitters such as dopamine in the brain's reward pathways (Winter et al., 2023).

However, this temporary relief is often followed by guilt or regret, as the individual becomes aware of the negative consequences that accompany their behavior—whether it be health problems, strained relationships, or financial difficulties. This guilt can evoke further emotional distress, which in turn may act as a new trigger, thereby restarting the cycle of craving and compulsive behavior. This repeating cycle illustrates how addiction not only alters neurobiological mechanisms but also shapes behavioral patterns, leading individuals into entrenched paths that are difficult to escape (Torres-Berrío et al., 2018). Understanding this cycle is crucial for developing effective interventions and therapeutic strategies aimed at breaking the repetitive nature of addictive behaviors,

such as mindfulness techniques or cognitive-behavioral therapies that target the mechanisms of craving and maladaptive coping strategies (Garland et al., 2014).

5.1.2. Negative reinforcement cycle

The addiction cycle is fundamentally characterized by alternating phases of compulsive drug use and withdrawal, leading to a self-reinforcing cycle driven by both positive and negative reinforcement mechanisms. Negative reinforcement specifically pertains to the aversive states engendered by withdrawal symptoms, which drive individuals to consume substances to alleviate these undesirable experiences. This behavioral pattern is well-documented across various substances of abuse, including opioids, alcohol, and nicotine.

The concept of negative reinforcement in addiction is elucidated through the roles of neurobiological and psychological processes. According to Koob and colleagues, the addiction progression can be delineated into three critical stages: binge/intoxication, withdrawal/negative affect, and preoccupation/anticipation. The latter two stages are primarily influenced by negative reinforcement mechanisms stemming from the adverse emotional states associated with withdrawal (Koob, 2021). As individuals enter the withdrawal phase, the dysregulation of brain reward pathways, particularly in the extended amygdala and the nucleus accumbens, leads to heightened negative emotional states often described as hyperkatifeia, a concept reflecting severe negative affect during withdrawal.

5.1.3. Pleasure-Seeking & Pain-Avoidance Model

The cycle of addiction is fundamentally grounded in the dual mechanisms of seeking pleasure and avoiding pain, which are intricately linked to the neurobiological and psychological processes underlying addictive behaviors. This interplay underscores the complexity of addiction as not merely a quest for pleasure but also a significant effort to alleviate distress and emotional pain. In the context of addiction, positive reinforcement is typically associated with the pleasurable effects of substance use, which stimulates the brain's reward system, primarily mediated by dopamine pathways in areas such as the nucleus accumbens. However, as individuals continue to engage in substance use, the need for positive emotional states can transition into a reliance on substances as a form of negative reinforcement. When the effects of the substance wear off, withdrawal symptoms emerge, prompting a painful psychological state that individuals seek to avoid by returning to substance use (May et al., 2020). This cycle exemplifies the dual nature of addiction, where pleasure seeking in the initial stages is overshadowed by an overwhelming drive to escape negative affective states in later stages.

Research indicates that factors such as impulse control, craving, and stimulus-response learning play crucial roles in this cyclical pattern. Newton et al. emphasize that while pleasure-seeking is a vital motivator for continued drug use, it coexists with other motivational elements that influence relapse, such as the experienced stress and frustration in the absence of the drug (Newton et al., 2009). Negative reinforcement mechanisms become particularly potent during abstinence, where individuals often experience a resurgence of negative emotional states, contributing to cravings and a higher likelihood of relapse (May et al., 2020).

Furthermore, neurocircuitry associated with addiction shows significant changes due to repeated exposure to substances, where reward systems become dysregulated. This dysregulation not only supports the ongoing seeking of pleasure through substance use but also diminishes the brain's ability to evaluate and respond appropriately to natural rewards in the environment. Over time, the individual may develop a compulsive drive for drug use that is difficult to manage, as demonstrated in the work by Koob, who highlights the transition from positive to negative reinforcement as addiction progresses (Koob, 2001).

In essence, the addiction cycle illustrates how the model of seeking pleasure is intricately coupled with the avoidance of pain. It is crucial to understand that addiction mechanisms extend beyond mere desire for pleasure and emphasize a broader context where social, psychological, and neurobiological factors influence behavior. Hence, interventions aimed at treating addiction must consider both the hedonic consequences of drug use and the aversive states that often drive individuals back to substance use (Volkow et al., 2003).

5.1.4. Automatic thought – impulse relationship

The relationship between automatic thoughts and impulsive behaviors is pivotal in understanding the cycle of addiction. Addiction often develops as impulsive behavior directed towards substance use, informed by automatic thoughts that minimize potential risks and emphasize immediate rewards. This impulsivity is deeply intertwined with negative reinforcement, which serves to perpetuate addictive behaviors as individuals seek to escape from unpleasant emotional states or withdrawal symptoms.

Research indicates that impulsivity is a significant predictor of addiction, as impulsive individuals are more likely to engage in behaviors without fully considering the consequences (Belin et al., 2008). The work by Belin et al. highlights that high levels of impulsivity increase the likelihood of transitioning from occasional to compulsive drug use, illustrating the critical shift in behavior patterns associated with addiction (Belin et al., 2008). Such impulsivity is linked to dysfunctions in neuroanatomical structures, particularly the prefrontal cortex, which is responsible for moderating impulses and decision-making processes. As individuals increasingly rely on substances for a quick emotional reprieve, automatic thoughts about the drug's efficacy in providing immediate relief can further entrench their impulsive behaviors.

Moreover, automatic thoughts often arise in response to adverse emotional states, perpetuating a cycle of avoidance that leads individuals back to substance use. The interplay between negative emotions and impulsivity is well-documented; individuals may

experience discomfort or distress that triggers automatic negative thoughts, which in turn prompts impulsive behavior in the form of substance consumption to alleviate that distress (Stotts et al., 2015). The inability to manage these automatic thoughts and urges contributes significantly to the maintenance of substance use disorders.

Neurobiological mechanisms also underpin the impulsive thought-action patterns observed in addiction. Oleson et al. elaborate on how dopaminergic systems are affected during withdrawal, illustrating that dopamine release events encode conditioned cues that can drive compulsive behaviors (Oleson et al., 2014). This dynamic highlights how the brain's reward pathways can become dysregulated through repeated substance use, making it increasingly difficult for individuals to control their impulses in the face of cravings or withdrawal symptoms (Koob, 2001). Furthermore, the framework discussed by Gardner emphasizes the transition from impulsive to habitual drug-seeking behaviors as the brain's reward systems become more sensitive to substance-related cues, reinforcing the automatic thought patterns that accompany addictive behaviors (Gardner, 2011).

In summary, the automatic thought-impulse relationship in addiction reflects a multidimensional interplay of psychological and neurobiological factors. Impulsivity enhances the likelihood of acting on automatic thoughts that favor substance use as a coping mechanism for negative emotional states. Over time, this relationship can lead to compulsive use and a deteriorating capacity to make adaptive decisions, laying the groundwork for enduring addiction. Various interventions targeting improvements in impulse control and cognitive restructuring may help disrupt this cycle, reduce addictive behaviors, and promote healthier coping strategies.

5.2. The Relationship Between Impulse Control Disorders and Addiction

5.2.1. Gambling addiction, shopping addiction, technology addiction

The landscape of impulse control disorders (ICDs) reveals significant overlap with various forms of addiction, including gambling, eating, shopping, and technology addiction. Each of these disorders is characterized by an inability to manage impulses effectively, leading to behaviors that often culminate in harmful consequences. Given the shared underlying mechanisms, understanding these relationships highlights the importance of addressing impulsivity in therapeutic contexts.

Gambling Addiction

Gambling addiction, classified as "gambling disorder" in the DSM-5, exhibits impulsivity as a core feature. Pathological gambling shares neurobiological mechanisms with substance addictions, including dysregulation of reward pathways and changes in impulsivity-related areas of the brain (Lee et al., 2012) . Research indicates that individuals with gambling disorders have heightened levels of impulsivity, which predispose them to risk-taking behaviors and difficulty in controlling gambling urges (Choi et al., 2014). This impulsive behavior reflects a tendency to prioritize short-term rewards over long-term consequences, a pattern observed across various impulse control disorders.

Eating Addiction

Compulsive eating, particularly binge eating disorder (BED), also displays characteristics consistent with impulse control disorders. Studies have found that individuals exhibiting addictive-like eating behaviors often exhibit high levels of impulsivity, similar to those seen in substance and gambling addictions (Mantilla et al., 2021). For instance, Mantilla et al. reported that emotional dysregulation is a significant mediating factor between impulsivity and addictive behaviors related to food (Mantilla et al., 2021). This suggests that individuals may resort to food for immediate relief in ways akin to gambling or substance use as a means to cope with emotional distress.

Shopping Addiction

Compulsive shopping, also referred to as "oniomania," is characterized by uncontrollable urges to shop, often leading to negative consequences in an individual's financial and social life. The disorder exhibits both impulsive and compulsive properties, similar to those found in gambling addictions. According to a Delphi expert consensus study, compulsive shopping behavior mirrors other impulse control disorders, with individuals often acknowledging the harmful outcomes yet feeling powerless to resist their urges to purchase (Müller et al., 2021). This reflects an underlying discord between conscious recognition of harm and impulsive behavior driven by immediate gratification.

Technology Addiction

Technology addiction encompasses various forms, prominently including internet and gaming addiction, which have increasingly been recognized as impulse control disorders. Multiple studies, including those by Lee et al. and Cao et al., have established a clear link between high impulsivity and internet addiction, suggesting that individuals with internet addiction may exhibit abnormal glucose metabolism in brain areas tied to impulse control (Lee et al., 2012). Implicit in these patterns is the tendency for people with high impulsivity to engage in excessive technology use as a coping mechanism for boredom or emotional distress, similar to behaviors observed in gambling and eating disorders.

The relationship between impulse control disorders and different forms of addiction reveals a complex interplay of behavioral tendencies that prioritize immediate gratification, despite awareness of potential negative outcomes. As each disorder engages common neurobiological and psychological frameworks, interventions focusing on impulse control could offer significant benefits across various types of addiction. Further research is essential to explore targeted strategies that may assist individuals in developing healthier coping mechanisms while managing impulsivity.

5.2.2. Relationship with obsessive-compulsive behaviors

The relationship between impulse control disorders (ICDs) and addiction is multifaceted, particularly when considering the intersection with obsessive-compulsive behaviors (OCBs). Both ICDs and OCBs often involve maladaptive patterns of behavior that can lead to significant personal and social distress. Understanding their interplay is essential for developing effective treatment approaches for individuals exhibiting symptoms of both categories.

Impulse Control Disorders and Obsessive-Compulsive Behaviors

Impulse control disorders are characterized by the inability to resist a temptation, urge, or impulse that may harm oneself or others. Common examples include gambling disorder, kleptomania, and pyromania. In contrast, obsessive-compulsive behaviors are defined by persistent, unwanted thoughts (obsessions) that prompt repetitive behaviors (compulsions) aimed at mitigating distress caused by these thoughts. Both conditions share underlying themes of difficulty in self-regulation and can co-occur, complicating the clinical presentation and treatment outcomes.

Multiple studies suggest that individuals with ICDs often display obsessive-compulsive traits. For instance, research by Grant et al. found a significant overlap between gambling disorders and obsessive-compulsive symptoms, indicating that those with gambling addiction may engage in compulsive behaviors as a coping mechanism for anxiety or intrusive thoughts related to their gambling. This relationship underscores the concept that impulsive actions can share a common neurobiological basis with compulsive behaviors, involving dysregulation within the dopaminergic pathways and frontostriatal circuitry.

Neurobiological Underpinnings

The neurobiological mechanisms that contribute to both ICDs and OCBs highlight their relationship. Neuroimaging studies suggest that similar brain structures, including the orbitofrontal cortex, anterior cingulate cortex, and striatum, are implicated in both impulse control and obsessive-compulsive behaviors. These areas are vital for decision-making, reward processing, and error detection, and their dysregulation can lead to the compulsive nature of both disorder types. Furthermore, dopamine dysregulation, particularly in the context of reward-seeking behavior, also connects the two disorders, suggesting that both impulsive and compulsive behaviors are manifestations of an underlying disruption in motivational processes.

The relationship between impulse control disorders and obsessive-compulsive behaviors reveals a complex interplay marked by shared neurobiological mechanisms, similar behavioral patterns, and co-occurrence in clinical populations. Addressing this relationship through integrated treatment approaches is crucial for improving outcomes for affected individuals, illustrating the need for ongoing research into the interconnected nature of these disorders.

5.2.3. Risk-taking behaviors

Risk-taking behaviors serve as a crucial link between impulse control disorders (ICDs) and addiction, characterized by the tendency to engage in actions that potentially lead to negative consequences. These behaviors are often driven by impaired impulse control and a heightened sensitivity to immediate rewards at the expense of long-term outcomes. Studies have demonstrated that individuals with gambling disorders exhibit significant risk-taking tendencies, which prolong their engagement in harmful behaviors despite adverse financial and social consequences. Similarly, risk-taking is a salient feature of internet gaming disorder; individuals with this condition often display poor decision-making skills and impulsivity, resulting in a preference for immediate gratification over reflective choices (Zeng et al., 2023). Furthermore, research indicates that risk-taking behaviors can be exacerbated in the context of substance use and other impulse control issues, suggesting a pervasive style of decision-making that prioritizes short-term rewards, reflecting a broader pattern of addiction-related behaviors (Grassi et al., 2015). This understanding underscores the importance of addressing risk propensity in treatment and prevention strategies for individuals affected by both ICDs and addiction.

5.2.4. Instant gratification

Instant gratification is a significant psychological factor linking impulse control disorders (ICDs) and various forms of addiction, characterized by the immediate fulfillment of desires without consideration for long-term consequences. Individuals with ICDs, such as gambling disorder and compulsive buying, often exhibit a heightened propensity toward instant gratification, leading them to prioritize short-term rewards despite potential negative impacts (Ioannidis et al., 2019; . This tendency is amplified by impaired impulse control, which not only facilitates engagement in addictive behaviors but also reinforces them, creating a cycle of behavior that is difficult to break (Choi et al., 2019). Neurobiologically, impulsive individuals display abnormalities in the brain regions responsible for reward processing and decision-making, perpetuating the cycle of seeking immediate rewards through harmful behaviors, as seen in both substance addiction and impulse control disorders (Ioannidis et al., 2019; , Asaoka et al., 2020). As a result, understanding and addressing the desire for instant gratification is crucial in formulating effective therapeutic interventions for those struggling with both addictions and impulse control disorders.

5.3. Trauma-Based Addiction (Self-Soothing Model)

5.3.1. Emotional States That Trauma Cannot Regulate

The concept of emotional states that trauma cannot regulate is a critical area of study within trauma-informed approaches, particularly in understanding the dynamics of trauma-based addiction. Trauma often leaves individuals with severe emotional

dysregulation, impairing their ability to manage and express feelings effectively. This incapacity can predispose them to various forms of addiction as a means of self-soothing and coping.

Research indicates that individuals who have experienced trauma, particularly in childhood, frequently exhibit difficulties in emotion regulation. This often translates to maladaptive coping mechanisms, such as substance use or compulsive behaviors like internet or food addiction. For instance, children subjected to emotional abuse may develop a lack of confidence in their emotional regulation abilities, subsequently leading them to seek comfort in addictive behaviors such as excessive internet use (Estévez et al., 2017).The interplay between trauma and addiction is underscored by findings suggesting that emotional dysregulation acts as a mediator in this relationship, highlighting both direct and indirect effects of trauma on addiction symptoms (Gürgen et al., 2022). Importantly, studies reveal that the inability to regulate emotions can significantly influence one's engagement in addictive behaviors. Difficulty in managing emotional responses, such as impulsivity or rumination, often drives individuals towards self-soothing practices that may manifest as problematic substance use or behavioral addictions (Hardy et al., 2018) . This pattern reflects broader research indicating that the biological and psychological repercussions of trauma—such as changes in reward circuitry—can enhance vulnerability to addiction, further complicating the emotional landscape (Hardy et al., 2018). The implications of early adverse experiences suggest that individuals with a history of childhood trauma are at an elevated risk of developing addiction, as their emotional regulation skills may be severely compromised (Maté, 2012).

In summary, the relationship between trauma and emotion regulation is integral to understanding trauma-based addiction. Individuals struggling with the emotional aftermath of trauma often find themselves unable to self-soothe effectively, leading them to engage in maladaptive behaviors as a means of coping. Addressing these issues requires a nuanced understanding of the interplay between traumatic experiences and emotional dysregulation, as highlighted by various studies in the field.

5.3.2. Addiction As Avoidance Behavior

Addiction, particularly as it relates to avoidance behavior, is intricately linked to the psychological strategies individuals employ to cope with distressing emotions. Many individuals turn to addictive behaviors as a mechanism for escaping or alleviating negative emotional states, conceptualized as avoidance. Research indicates that coping strategies characterized by avoidance can lead to increased reliance on addictive behaviors in various contexts, including substance use and behavioral addictions.

For instance, adolescents exhibiting maladaptive coping strategies, such as self-blame and rumination, often engage in addictive behaviors like gaming or internet use as a means to escape emotional distress (Estévez et al., 2019). These avoidant coping mechanisms serve to temporarily distract or detach individuals from their negative feelings, albeit at the cost of potentially exacerbating the underlying emotional issues over time. Such behaviors are particularly prevalent among individuals exposed to stressful life events, where avoidance strategies serve as a direct response to emotional pain and discomfort (ARAYICI & Sütçü, 2025) The failure to effectively regulate emotions is another contributory factor that may reinforce the cycle of addiction as avoidance behavior. Individuals with higher levels of experiential avoidance tend to struggle more with managing their emotions, leading to a greater likelihood of developing substance use disorders or behavioral addictions (Mohammadkhani et al., 2016). This phenomenon suggests that the urge to engage in addictive behaviors can be understood as a maladaptive attempt to navigate emotional challenges, wherein the avoidance strategies employed may provide short-term relief but contribute to long-term psychological distress (Estévez et al., 2017).

Moreover, personality traits such as neuroticism are often correlated with difficulties in emotion regulation and increased tendencies toward behavioral avoidance. These traits can predispose individuals to use addictive behaviors as a coping strategy, reinforcing their reliance on such behaviors in the face of emotional challenges. There is significant empirical support for the notion that emotional regulation difficulties serve as mediators in the relationship between trauma, stress, and addiction (Kuz et al., 2022).

In conclusion, the framework of addiction as avoidance behavior underscores the critical role of coping strategies in shaping individuals' responses to negative emotions. The interplay of emotional dysregulation, personality factors, and situational stressors can create an environment where addiction becomes a preferred method for sidestepping emotional pain. Understanding this connection is essential for developing effective interventions that address both the addictive behaviors and the emotional difficulties that drive them

5.3.3. Attachment Styles (Especially Obsessive And Anxious Attachment)

Attachment styles significantly influence individuals' emotional regulation and interpersonal relationships, particularly regarding addiction behaviors. Anxious and obsessive attachment styles, in particular, have been recognized for their potential impact on psychological well-being and are often linked to maladaptive coping mechanisms, including addictive behaviors.

Individuals with anxious attachment styles tend to exhibit heightened sensitivity to relationship dynamics and often fear rejection or abandonment. This predisposition can lead to emotional dysregulation, where individuals struggle to manage their emotions effectively. Research highlights that anxious attachment is associated with increased levels of psychopathological issues, such as anxiety and depression. These emotional challenges can culminate in a reliance on substances or behaviors as self-soothing mechanisms, creating a cycle where addiction becomes a means to escape overwhelming emotional discomfort (Gori et al., 2023).

Obsessive attachment, characterized by preoccupation with relationships and a compulsive need for reassurance, similarly contributes to the development of addictive behaviors. This attachment style often correlates with a lack of emotional regulation skills, leading individuals to engage in compulsive behaviors—such as substance use or gambling—as maladaptive attempts to manage their anxiety and compulsions (Gori et al., 2023;Nielsen et al., 2025). Studies indicate that both anxious and obsessive attachment styles are linked to difficulties in emotion regulation, which further reinforces the cycle of addiction (Nielsen et al., 2025).

Attachment styles can thus be viewed as foundational elements influencing how individuals respond to emotional distress. Those with insecure attachment styles—whether anxious or obsessive—are more likely to engage in avoidance strategies that include addictive behaviors, as these provide temporary relief from negative emotional states, yet perpetuate long-term dysfunction (Caretti et al., 2018). This understanding reflects the crucial interplay between attachment, emotional regulation, and addiction, underscoring the need for therapeutic approaches that address these underlying relational patterns to foster healthier coping mechanisms.

5.3.4. The İmpact of Childhood Neglect And Abuse

The impact of childhood neglect and abuse is profound and multifaceted, influencing emotional and psychological development that can manifest in various maladaptive behaviors, including addiction. Research indicates that adverse childhood experiences (ACEs), particularly neglect and abuse, significantly shape interpersonal relationships and coping styles in later life.

Childhood neglect, encompassing emotional and physical forms, often disrupts the development of secure attachment patterns, leading to insecure attachment styles such as anxious and avoidant types. These insecure attachment styles are frequently linked to difficulties in emotional regulation and increased vulnerability to mental health disorders, including addiction. For instance, individuals who experience neglect may develop heightened anxiety about relationships, leading them to seek conditional validation and reassurance, which can precipitate compulsive behaviors, including substance use as a means of self-soothing (Erözkan, 2016).

Abuse, particularly emotional and physical maltreatment, enhances the risk of developing psychopathological issues in adulthood. Reports indicate a correlation between childhood maltreatment and emotional regulation problems, evidenced by higher instances of post-traumatic stress disorder (PTSD) symptoms and various mood disorders in those with abuse histories. Emotional abuse is particularly damaging, as it can instill a pervasive sense of low self-worth and contribute to the development of maladaptive coping strategies, such as excessive reassurance seeking or compulsive behaviors, which are often observed in individuals with borderline personality disorder (Erkoreka et al., 2021).

Both forms of childhood adversity create an environment where individuals may turn to substances or compulsive behaviors as a maladaptive strategy to cope with emotional pain, reflecting broader patterns of avoidance and dysregulation. Ultimately, the psychological sequela of childhood neglect and abuse calls for a nuanced understanding of how these experiences resonate through adult attachment styles and emotional responses, underlining the necessity for targeted therapies that address both trauma and addiction (Cook et al., 2017).

5.4. Cognitive Distortions

Cognitive distortions significantly contribute to the perpetuation of addiction by shaping individuals' perceptions and beliefs regarding their behavior and its consequences. These distortions often create a false sense of security or justification for engaging in addictive behaviors, making them critical to understand in the context of addiction.

The belief that "it won't hurt to try it once" exemplifies a common cognitive distortion wherein individuals downplay the risks associated with experimentation. This rationalization can lead to impulsive decisions that initiate a trajectory toward addiction. Research has shown that such minimization of harm is prevalent among those who engage in various addictive behaviors, including substance use (Giancola et al., 1999)

Another cognitive distortion commonly associated with addiction is "the illusion of control." This distortion involves an exaggerated confidence in one's ability to control their use of an addictive substance or behavior, despite evidence to the contrary. Individuals may convince themselves that they can manage their consumption or limit their behavior, leading to a cycle of dependency as they repeatedly overestimate their self-regulation capabilities. Studies indicate that this illusion often plays a pivotal role in the escalation of addictive behaviors and highlights a disconnect between perceived and actual control over substance use (Miller et al., 2016).

The notion that "if I quit, I'll feel empty" reflects an underlying fear of loss that can sustain addiction. This belief reinforces the idea that the addictive substance or behavior provides emotional fulfillment or identity, making the prospect of quitting seem threatening and undesirable. This cognitive distortion can hinder individuals from seeking help, as they may believe that abstinence would lead to an unmanageable sense of emptiness or anxiety (Snagowski & Brand, 2015).

Lastly, the distortion of exaggerating rewards while minimizing harm is prevalent in addiction narratives. Individuals often focus on the pleasurable outcomes of their behavior, such as temporary relief from stress or enjoyment, while ignoring the significant negative consequences, such as health issues or relationship strain. This skewed perception can lead to continued engagement in

addictive habits despite adverse effects. For example, the allure of gambling may overshadow financial losses and emotional distress, prompting individuals to rationalize their behavior in light of perceived temporary gains (Burleigh et al., 2019).

In summary, cognitive distortions operate as pivotal mechanisms in addiction, serving to justify maladaptive behaviors and sustain addictive cycles. Understanding these distortions is crucial for developing effective therapeutic interventions that aim to alter maladaptive thought patterns and promote healthier coping strategies.

6. BIOPSYCHOLOGICAL INTERACTION MODEL

6.1. Brain – Behavior Bidirectional Interaction

The interaction between brain structures and behavior is pivotal to understanding addiction through a biopsychological lens. This relationship emphasizes how behavioral choices not only influence brain function and structure but also highlights how neurological alterations can affect subsequent decision-making processes.

6.1.1.Behavior Altering Brain Structure

Engagement in specific behaviors, including those associated with substance use or other addictions, can induce neuroplastic changes in the brain. These changes manifest as adaptations in neuronal connectivity and responses associated with various stimuli, reinforcing habitual behavior. Research has established that chronic substance use, for instance, can result in alterations in brain areas responsible for executive functioning and impulse control, such as the prefrontal cortex (Beerten-Duıjkers et al., 2021) . Furthermore, when individuals engage in compulsive behaviors, they may experience structural brain changes that perpetuate the cycle of addiction, underscoring the bidirectional nature of this interaction (Noël et al., 2013).

6.2.2. Changes in the Dopamine System Weakening Impulse Control

The dopamine system plays a crucial role in addiction, with its influence extending beyond mere reward processing. Chronic exposure to addictive substances can lead to dysregulation of this system, adversely affecting impulse control. Studies reveal that alterations in dopamine receptor availability and signaling can decrease the efficacy of the prefrontal cortex, which is vital for inhibitory control (Beerten-Duıjkers et al., 2021). Consequently, impairments in this region can enhance impulsivity and decrease the ability to resist addictive behaviors. This dysfunction often results in a heightened susceptibility to cravings, as individuals may rely on immediate gratification rather than considering long-term consequences (Noël et al., 2013).

6.1.3 Reward Expectations Shaping Cognitive Processes

Cognitive processes are significantly influenced by expectations related to rewards, which are shaped by previous experiences with substances or behaviors. The anticipation of pleasure from engaging in addiction-related behaviors often leads individuals to overlook potential negative outcomes, fostering a distorted perspective (McClure & Bickel, 2014). This phenomenon involves the mesolimbic pathway, where dopaminergic activity reinforces the likelihood of repeating certain behaviors based on anticipated rewards. Over time, these reward-driven cognitive distortions can become ingrained, undermining rational decision-making processes and perpetuating addiction cycles (McClure & Bickel, 2014).

In conclusion, the brain-behavior bidirectional interactions illustrate a complex relationship where behavior impacts neural structure and function, and vice versa. Understanding these interactions is crucial for developing effective interventions for addiction, as they highlight the importance of addressing both behavioral patterns and corresponding neurological changes.

6.2. Emotion Regulation Disorders in Addiction

Emotion regulation disorders are prevalent among individuals struggling with addiction, often manifesting as anger, anxiety, and feelings of emptiness. These emotional dysregulations can exacerbate addiction behaviors, leading to a cycle of increased substance use as a means of coping with intense feelings. Specifically, anger and anxiety are frequently reported emotional states among individuals with substance use disorders (SUDs), contributing to a higher propensity for impulsivity and aggression, which may contribute to the maintenance and exacerbation of their addiction (Çiftçi & Fırat, 2023).

Individuals with addiction often experience emotional numbness, which has been linked to a phenomenon known as "hedonic dysregulation," where the motivation to seek pleasure from substance use overshadows the ability to experience pleasure from everyday activities. This inability to derive satisfaction from natural rewards can lead to further dependence on substances to cope with emotional voids. As Garland and colleagues noted, hedonic dysregulation is a characteristic of addiction, as individuals increasingly seek drug-related rewards while neglecting other rewarding experiences (Garland et al., 2019).

Moreover, decreased stress tolerance is common among those with addiction, with research highlighting how impaired executive function contributes to difficulties in managing stress and regulating emotions. This decreased tolerance can make individuals more susceptible to emotional triggers, leading to heightened cravings. Starcke et al. emphasized the role of cue-reactivity in various forms of addiction, suggesting that specific cues can elicit compulsive behaviors and cravings, which are often intertwined with emotional states like anxiety and anger (Starcke et al., 2018). Such emotional triggers reinforce the cycle of addiction as the individual turns to substances in an effort to regulate their emotional responses (Hubert et al., 2023).

The interplay between emotional states and addiction illustrates a complex relationship where emotional numbing can impair an individual's ability to effectively manage their emotions, leading to a reliance on substances to achieve a semblance of emotional

stability. Polarized emotions, such as extreme sadness or anger, tend to precipitate the onset of substance use and can maintain its cycle by acting as precursors to relapse in recovering individuals (Çiftçi & Fırat, 2023). Understanding these emotional regulation disorders within the context of addiction is crucial for developing effective therapeutic interventions aimed at helping individuals restore their emotional equilibrium while reducing their dependence on substances.

6.3. Social and Environmental Foundations of Addiction

The social and environmental foundations of addiction can be understood through a multifaceted lens that encompasses social learning, family attitudes, social rewards influenced by social media, and the fast-paced modern consumption cycle. Each of these factors plays a critical role in the development and persistence of addictive behaviors.

Social learning theory emphasizes that behaviors, including substance use and other forms of addiction, can be acquired through observation and imitation of others. This is evident in familial settings where the attitudes toward substance use can significantly shape an individual's risk for addiction. Children often model parental behaviors, leading to the internalization of addiction as a normative behavior if parents exhibit substance use as a coping mechanism or a form of social engagement. Moreover, adverse early life experiences and emotional dysregulation have been shown to increase vulnerability to addictive behaviors, with marginalized and dysfunctional family dynamics further exacerbating this risk (Loreto et al., 2024).

Modern social dynamics, particularly through social media, have introduced new avenues for addiction. The use of platforms can trigger social rewards, reinforcing addictive behaviors as individuals seek validation through likes and shares, which engender feelings of worth and pleasure. Hormes et al. found a strong connection between social media addiction and difficulties in emotion regulation, suggesting that individuals may use social media as a maladaptive strategy to cope with negative emotional experiences (Hormes et al., 2014). As such, the reinforcement from social networks can create a feedback loop, whereby the very platforms that promise connection can lead to greater emotional isolation and dependency on substances or behaviors as additional coping strategies.

The rapid consumption cycle of contemporary life, characterized by immediacy and the glorification of instant gratification, also significantly influences addictive behaviors. Strulik discusses how the shortcuts to pleasure—ranging from food to technology—create an environment where long-term reward systems are neglected in favor of immediate satisfaction (Strulik, 2017). This shift reflects a broader cultural orientation towards quick pleasure, which reinforces addictive behaviors as individuals gravitate towards substances that promise rapid emotional relief. For example, the tendency to engage in pleasurable activities (including substance use) without adequate emotional regulation can lead to compulsive behaviors as the brain's reward pathways continually seek stimulation (Kun et al., 2022).

The interplay among social learning, familial influences, the allure of social media rewards, and the rapid pace of life creates a perfect storm for addiction. Over time, these factors can engrain maladaptive coping mechanisms, where individuals resort to substances or compulsive behaviors as their primary means of emotional regulation. Thus, understanding these foundations is essential in developing comprehensive prevention and treatment strategies that address not only the individual but also their social environment.

7. TREATMENT AND INTERVENTION APPROACHES

7.1. Psychotherapeutic Interventions

7.1.1. Cognitive Behavioral Therapy (CBT)

Cognitive Behavioral Therapy (CBT) is a well-established psychotherapeutic intervention utilized in the treatment of addiction, particularly effective for various forms of substance use and behavioral addictions, including internet and gaming addiction. CBT operates on the premise that maladaptive thoughts and behaviors can be identified and altered to improve emotional regulation and reduce compulsive behaviors associated with addiction.

Research indicates that CBT can significantly ameliorate symptoms of internet addiction in adolescents. A study conducted by Ding and Li highlights that CBT helps improve self-control, thereby reducing symptoms of internet addiction, anxiety, and depression among adolescents Ding & Li (2023). This is reinforced by findings from a systematic review conducted by Pérez-Wiesner et al., which emphasizes CBT's effectiveness in enhancing personal and social functioning while managing problematic use of digital technologies (Pérez-Wiesner et al., 2025). Such improvements suggest that CBT not only addresses immediate addictive behaviors but also instills lasting changes in cognitive processes and emotional responses.

CBT has also been tailored to address specific addictive behaviors. For instance, Humayya et al. note that the principles of CBT have been effectively applied to treat online gaming addiction, demonstrating its adaptability in addressing various types of behavioral addictions (Humayya et al., 2022). Furthermore, Ayub et al. affirm that CBT presents significant effectiveness in treating internet addiction, underscoring its applicability across different populations and age groups (Ayub et al., 2023).

The versatility of CBT is particularly evident in its application to substance use disorders. Dugosh et al. found in their systematic review that combining CBT with contingency management resulted in improved outcomes for individuals undergoing treatment for opioid addiction, suggesting that CBT can serve as a powerful adjunctive therapy in comprehensive treatment regimens. This

is consistent with findings from Kaminer and Burleson, who reported that adolescents receiving CBT showed significant improvements in substance-related disorders over a 15-month follow-up, highlighting the enduring benefits of this therapeutic approach (Kaminer & Burleson, 1999).

Moreover, the integration of CBT with technology-based interventions showcases its relevance in modern treatment paradigms. For example, applications that incorporate CBT principles are emerging as effective tools for addressing addictive behaviors, particularly in young populations (Haug et al., 2022). The adaptability of CBT in digital formats can enhance engagement and facilitate therapeutic processes in the context of increasing screen time and digital dependency in contemporary society.

Additionally, studies have pointed to certain neurobiological correlates of CBT effectiveness in treating internet gaming disorder, demonstrating that treatment leads to changes in brain activity associated with compulsive behaviors (Han et al., 2018). This intersection of psychological and neurological observations provides support for the effectiveness of CBT, indicating that its benefits extend beyond mere symptom relief to include profound changes in cognitive and emotional processing.

Overall, CBT has solidified its role as a cornerstone intervention in both substance use and behavioral addictions. Its empirical support across diverse settings, coupled with adaptability to modern challenges posed by technology and changing social landscapes, highlights its enduring relevance and effectiveness as a therapeutic modality for addressing addiction.

7.1.2. Motivational Interviewing

Motivational Interviewing (MI) has emerged as a significant psychotherapeutic intervention in addiction treatment, characterized by its collaborative, client-centered approach that seeks to enhance an individual's motivation for change regarding substance use or addictive behaviors. Existing literature underscores the effectiveness of MI across various types of addiction, including substance use disorders and behavioral addictions such as gambling and internet addiction.

The application of MI often coexists with other therapeutic modalities. For instance, Ayub et al. discuss its combination with Cognitive Behavioral Therapy (CBT) and mindfulness-based interventions, highlighting significant improvements in related symptoms of anxiety and depression among children and adolescents with internet addiction (Ayub et al.,2023). Similarly, a systematic review by Frost et al. confirmed the effectiveness of MI within health and social care settings, particularly in relation to gambling and substance use behaviors (Frost et al.,2018).

The principles underlying MI advocate for a non-confrontational stance, where therapists help clients explore their ambivalence towards change. Motivation itself is a well-recognized predictor of recovery success. As noted by Diclemente et al. (DiClemente et al., 2017), MI's focus on enhancing intrinsic motivation facilitates movement toward behavioral change by allowing clients to articulate their thoughts and feelings around addiction, thereby fostering a greater commitment to treatment and recovery.

Furthermore, MI is particularly valuable in high-stigma populations, such as those with alcohol use disorder. It has been shown that integrating MI into treatment settings—combined with immediate engagement techniques like inpatient addiction consult services—can elevate the likelihood of treatment entry and adherence among patients (Weinstein et al., 2018). This strategy captures patients during moments of heightened vulnerability, making MI an effective tool in promoting behavioral change in real-time.

Research evaluating the prevalence of MI in standardized treatment protocols for addiction indicates a strong reliance on this technique. MI is commonly utilized not only as a standalone intervention but also synergistically with other established methods, including family therapy and brief interventions. In addressing co-occurring issues of anxiety or depression with addiction, MI can enhance the effectiveness of concurrent therapies (DiClemente et al., 2017).

Thus, MI stands out as a versatile and empirically supported intervention in addiction treatment, demonstrating effectiveness across various contexts and populations. By engaging individuals in their motivational landscape, MI facilitates a personalized and empathetic route to recovery, making it an indispensable part of contemporary addiction treatment strategies.

7.1.3. Dialectical Behavior Therapy (DBT)

Dialectical Behavior Therapy (DBT) is an evidence-based psychotherapy initially developed for the treatment of borderline personality disorder (BPD). It has been effectively adapted for substance use disorders (SUDs), addressing the interconnectedness of emotional dysregulation and addictive behaviors (Lee et al., 2015). Central to DBT are focused strategies that promote both acceptance and change, which are essential in assisting individuals managing the turbulent emotional landscape associated with addiction. DBT employs a structured framework that includes individual therapy, skills training groups, and telephone coaching, providing a comprehensive support system for those in recovery (Lee et al., 2015).

The primary goal of DBT in the context of addiction treatment is to enhance emotional regulation, reduce impulsivity, and mitigate self-destructive behaviors related to substance use. This therapeutic modality emphasizes the development of mindfulness skills that equip individuals to remain present and manage their emotions more effectively. Research has shown that individuals undergoing DBT demonstrate significant reductions in substance use and improvements in psychosocial functioning (Nezhad et al., 2019). Additionally, DBT's skills training targets critical risk factors for relapse by fostering interpersonal effectiveness and distress tolerance, enabling individuals to respond adaptively to stressors that may trigger cravings or initiate substance use (Nezhad et al., 2019). The integration of these components creates a robust framework for fostering long-term recovery from

addiction, highlighting the effectiveness of DBT as a suitable intervention for those grappling with both SUDs and co-occurring emotional disorders (Lee et al., 2015).

Dialectical Behavior Therapy offers a multifaceted approach to addiction treatment that integrates essential skills for emotional and behavioral regulation. Its systematic structure, combining individual therapy with group skills training, enables individuals to effectively confront and manage the emotional challenges that accompany their substance use disorders. The evidence supporting DBT's utility and effectiveness in this realm underscores its potential as a transformative intervention for promoting lasting recovery.

7.1.4. Mindfulness and awareness-based methods

Mindfulness and awareness-based methods have emerged as promising approaches for the treatment of addiction, offering individuals effective tools to manage cravings and emotional distress related to substance use disorders (SUDs). Mindfulness, characterized by non-judgmental awareness of the present moment, fosters a deeper understanding of one's thoughts, feelings, and bodily sensations, which can help individuals respond rather than react to situations that trigger substance use Dragland (2015). Interventions such as Mindfulness-Based Relapse Prevention (MBRP) blend mindfulness practices with cognitive-behavioral strategies to enhance emotional regulation and coping mechanisms. Research demonstrates that mindfulness skills can significantly reduce anxiety, depression, and stress—all factors that contribute to the risk of relapse. By cultivating skills such as acceptance and commitment to change, individuals can better navigate the complex emotional landscapes that often accompany addiction recovery (Bowen et al., 2009).

Interoceptive awareness—the ability to recognize and interpret internal bodily signals—plays a crucial role in addiction treatment. Studies suggest that enhancing interoceptive awareness can empower individuals to better manage cravings and emotional fluctuations that lead to substance use (Çöl et al., 2016). Individuals with stronger interoceptive awareness often have improved distress tolerance and coping skills, enabling them to avoid maladaptive behaviors such as substance use. Awareness-based therapies promote this enhanced understanding of bodily sensations through methods like body-focused meditations and reflective practices, thereby addressing the physical responses associated with cravings and withdrawal symptoms. Further, cultivating greater awareness of bodily signals can assist individuals in identifying early warning signs of relapse, allowing for timely intervention (Çöl et al., 2016). Overall, mindfulness and interoceptive awareness methods represent a critical complement to traditional therapeutic interventions in addressing addiction, facilitating a more comprehensive approach to recovery.

In conclusion, mindfulness and awareness-based interventions serve as effective strategies in the treatment of addiction by fostering emotional regulation, improving distress tolerance, and enhancing interoceptive awareness. These methods provide individuals with the necessary skills to navigate the challenges of addiction recovery, ultimately supporting sustained behavioral change.

7.2. Biological and Medical Approaches to Addiction

The treatment of addiction has benefited from a variety of biological and medical approaches, focusing primarily on pharmacological interventions, modulation of dopamine receptors, and neuromodulation techniques, as well as emerging concepts surrounding the brain–gut axis.

7.2.1. Pharmacological Interventions

Pharmacological interventions represent a cornerstone of addiction treatment. These medications often function to alleviate withdrawal symptoms, reduce cravings, or block the rewarding effects of substances. For example, opioid use disorder is commonly treated with medications such as methadone and buprenorphine, which act as agonists or partial agonists targeting opioid receptors in the brain to mitigate withdrawal symptoms while preventing the euphoric effects of illicit opioids Volkow et al. (2012). Another critical aspect is the use of naltrexone, an opioid antagonist that diminishes the reward associated with alcohol and opioid consumption, thereby reducing relapse rates (Leshner, 1997). Research has highlighted that potential treatment efficacy is often linked to an individual's unique neurobiological profile, which includes genetic factors influencing drug metabolism and receptor availability (Leshner, 1997).

7.2.2. Dopamine Receptor Modulation

Dopaminergic pathways are pivotal in the neurobiology of addiction, particularly in the context of reward and reinforcement processes. Studies indicate that individuals with various forms of addiction, including internet addiction and substance abuse, often exhibit reduced levels of dopamine D2 receptors, which correlates with the severity of their addiction. This reduction in receptor availability implies that addiction may impair the brain's reward circuitry, leading to a diminished response to natural rewards and reinforcing the consumption of addictive substances. Dopamine receptor modulation through pharmacotherapies, behavioral interventions, or neuromodulation techniques offers promise in re-establishing the balance of these pathways and reducing compulsive drug-seeking behavior (Sevy et al., 2006).

7.2.3. Neuromodulation Techniques

Neuromodulation techniques, such as deep brain stimulation (DBS), are gaining recognition as potential interventions for treatment-resistant addiction. DBS involves delivering electrical impulses to specific brain regions, such as the nucleus accumbens,

which is implicated in reward processing and craving. Initial case studies have demonstrated that DBS can lead to significant reductions in addictive behaviors, suggesting that modulating activity in key neural circuits may reset pathological reward mechanisms underlying addiction (Stelten et al., 2008). However, ethical considerations around invasive procedures necessitate continued research to assess the long-term safety and efficacy of neuromodulation techniques within addiction treatment (Stelten et al., 2008).

7.2.4. Brain–Gut Axis Support

Recent research has also begun to investigate the relationship between the gut microbiome and addiction through the brain–gut axis. Emerging studies suggest that probiotics and omega-3 fatty acids might play a role in modulating neural function and behavior, potentially impacting the onset and progression of addictive disorders (Kwako et al., 2018). The gut microbiome is thought to influence brain health and behavior by producing neurotransmitters and influencing systemic inflammation, both of which are linked to addiction processes (Kwako et al., 2018). Probiotics, for instance, have been shown to improve mood and cognitive functions, which could facilitate recovery from addiction by enhancing overall mental health (Fisher & Berkman, 2015). Thus, leveraging the brain–gut axis could represent a novel strategy in addressing addiction and promoting recovery.

In summary, the biological and medical approaches to addiction encapsulate a range of strategies aimed at mitigating the neurobiological disruptions caused by addictive substances. The integration of pharmacological treatments, modulation of dopaminergic systems, neuromodulation interventions, and support through brain–gut axis mechanisms offers a multifaceted approach to treating addiction and underscores the complexity of this chronic condition.

7.3. Lifestyle Adjustments

7.3.1. Restructuring Sleep Biology

Sleep disturbances are frequently observed in individuals undergoing recovery from addiction, contributing to a cycle of relapse and hindered rehabilitation progress. To effectively address these disturbances, it is essential to adopt strategies aimed at restructuring sleep biology. A strong relationship exists between physical activity and improved sleep outcomes. Engaging in regular physical exercise promotes the secretion of endorphins, which can mitigate addictive behaviors by competing with addictive substances for receptors in the central nervous system Zhao & Kou (2024). Furthermore, individuals with high levels of smartphone and internet addiction typically experience poorer sleep quality, as excessive screen time and sedentary behaviors lead to insomnia and chronic sleep deprivation (Rashid et al., 2025). Research has shown that enhancing sleep quality aids in mood stabilization and bolsters recovery efforts, emphasizing the critical role of sleep hygiene within addiction recovery frameworks (Rutkowska et al., 2024; .

Behavioral interventions, strategies, and therapies focused on recalibrating individuals' sleep-wake cycles can significantly enhance mental and physical health outcomes. Studies indicate that improving sleep quality through proper sleep hygiene education leads to reduced cognitive impairments associated with sleep loss, which is essential in addiction recovery (Rutkowska et al., 2024; Porter, 2021). Moreover, interventions such as light therapy have been demonstrated to effectively synchronize circadian rhythms and subsequently alleviate sleep disorders commonly afflicting recovering individuals (Lee et al., 2021).

7.3.2 Exercise, Serotonin, and Dopamine Balance

Physical exercise functions as a vital component in managing addiction recovery, particularly concerning the balance of serotonin and dopamine levels. Exercise has been shown to enhance neurotransmitter signaling, specifically dopamine, which is beneficial not only for mood improvement but also for reducing anxiety and depressive symptoms frequently encountered in individuals with substance use disorders (Núñez-Cortés et al., 2025; . The relationship between exercise and addiction has been described as a reinforcement mechanism; regular physical activity can serve as a viable alternative to substance use by stimulating dopamine release, thereby addressing the underlying reward deficits often present in addiction (Yu et al., 2025).

Furthermore, engagement in physical activities can foster improved core self-evaluations and overall life satisfaction, indirectly mitigating behavioral addictions such as smartphone dependency (Gong et al., 2023). Studies reveal that individuals participating in higher levels of physical exercise report lower degrees of addictive tendencies and improved emotional resilience (Bozkurt et al., 2017). The corresponding release of neuromodulatory compounds, including endorphins, serves to enhance emotional well-being and further promote a balanced neurochemical environment conducive to recovery (Núñez-Cortés et al., 2025; Alaca, 2020).

7.3.3. Nutrition Protocols

Nutritional interventions play a significant role in the overall treatment and management of addiction. Proper nutrition not only helps in repairing physiological damage caused by substance abuse but also supports psychological well-being, which is crucial during recovery. Research has demonstrated that individuals recovering from addiction often face nutritional deficiencies, which can exacerbate mental health issues, including depression and anxiety Patterson et al. (2022). For example, improved dietary habits have been shown to positively influence mood and cognitive function, contributing to a more stable recovery environment Karajibani et al. (2014).

Implementing specific nutritional protocols can enhance recovery outcomes by including whole foods, balanced macronutrients, and micronutrients essential for brain health. Dietary approaches that encompass omega-3 fatty acids, vitamins, and minerals have

been associated with neuroprotective effects, potentially reducing cravings and improving mood stability Juwono & Szabó (2020). Moreover, educational programs focusing on healthy eating behaviors have proven effective in modifying eating habits among individuals with substance use disorders, leading to enhanced physical health and mental resilience Karajibani et al. (2014).

Furthermore, attention to hydration and the timing of meals can influence metabolic health and mood modulation, which are critical during the recovery phase Herbert et al. (2023). Inadequate hydration, often overlooked, can significantly impact energy levels and cognitive functioning, leading to increased susceptibility to cravings and relapse. Thus, comprehensive nutritional strategies that incorporate education about proper nutrition, adequate hydration, and understanding the impact of food choices on mental health are vital when addressing addiction recovery Karajibani et al. (2014).

7.3.4 Social Support Systems

Social support systems are crucial for fostering long-term recovery from addiction. Research indicates that individuals who engage more with supportive social networks tend to have better treatment outcomes (Haglund et al.,2015;Patterson et al. 2022). Social support encompasses emotional encouragement, informational support, and practical assistance, all contributing to improved coping mechanisms in the face of stressors that may trigger relapse (Lichtenstein et al., 2012). For instance, group therapy and support groups such as Alcoholics Anonymous provide a platform where individuals can share experiences and strategies for managing cravings and avoiding relapse, thus enhancing feelings of connection and belonging (Lichtenstein et al. 2012).

The presence of a solid support system can lead to improved psychological outcomes. A meta-analysis of studies indicated that social support not only reduces the risk of relapse but also positively impacts mental health, promoting overall wellness among recovering individuals (Marcos et al., 2016). Participants with strong social connections exhibited lower levels of depressive symptoms and higher self-efficacy regarding their recovery journey Lichtenstein et al., 2012).

Moreover, social interactions facilitate the development of practical skills for daily living, essential for maintaining sobriety. Engaging in community-based activities can also represent a constructive outlet that replaces behaviors related to substance use Bueno-Antequera et al. (2020). This emphasizes the importance of integrating social support into treatment plans as a foundational element for fostering resilience and promoting successful adaptation to a lifestyle free from substances Lichtenstein et al. (2012).

Lifestyle adjustments incorporating improved sleep hygiene, exercise regimens, nutritional protocols, and robust social support systems play an essential role in addiction recovery. The synthesis of evidence from various studies underscores that a holistic approach—addressing physical health, mental health, and social connections—can significantly facilitate recovery and reduce the risk of relapse among individuals struggling with SUDs.

8. LIMITATIONS

This systematic review encountered some limitations in its assessment of the existing literature on the neurobiological basis of addictions and psychological impulse control disorders. First, the heterogeneity of the studies limits the generalizability of the results due to the use of different diagnostic criteria and methods. Since many studies were conducted with small sample groups, the reliability of the findings may be limited. Furthermore, the stability and computational accuracy of magnetic resonance imaging and other neuroimaging techniques are insufficient to fully reflect the complex dynamics of brain networks. Most studies have a cross-sectional design and reveal correlations rather than causality. Furthermore, individuals' clinical characteristics and comorbidities are other important factors that prevent clear results from being obtained. In addition, ethical and legal constraints, particularly restrictions on patient confidentiality and data sharing, make validation and replication difficult. Finally, the differences between animal models and human studies used in neurobiological research limit the clinical implications of the data obtained and complicate translation processes. For these reasons, it is not yet possible to use the results of current studies in a comprehensive and generally valid manner in cross-research, and the need for more comprehensive and controlled studies is clear. These limitations are significant constraints to the advancement of neurobiological basic research, and methodological developments and improvements in ethical protocols are needed to overcome them in the future.

9. DECLARATIONS AND ETHICAL STATEMENT

- **Review:** The article has been reviewed by internal and external reviewers in accordance with the principles of scientific integrity and transparency.
- **Conflict of Interest:** The authors have not reported any conflicts of interest.
- **Financial Support:** No financial support was used for this study.
- **Ethical Declaration:** The criteria of the Helsinki Declaration were taken into consideration.

10. DISCUSSION

The neurobiological basis of addiction is a complex structure shaped by a combination of both genetic and environmental factors. The role of dopamine in the motivation-pleasure mechanism is of great importance in understanding the fundamental structures of addiction processes. Key structures of the reward circuit, such as the ventral tegmental area (VTA), nucleus accumbens, and prefrontal cortex, play critical roles in the functionality of the dopamine system. Desensitization of dopamine receptors in the reward

system, combined with a loss of value in natural rewards, constitutes one of the fundamental reasons why individuals turn to substance or behavioral addictions (Lu et al. 2019; Wang et al., 2012).

Genetic predisposition is another important component of addiction. The presence of genes such as DRD2 and OPRM1 increases individuals' risk of developing addiction, and genetic research highlights the effect of familial predisposition on addictive behaviors (Avchalumov et al., 2020; Coune et al., 2016). Epigenetic changes and genetic activation patterns following trauma further increase individuals' sensitivity to addiction risk. Thus, genetic and environmental interactions appear to play a central role in the development of addiction.

Neuroplasticity is another important factor to consider in addiction treatment. Synaptic strengthening and weakening processes are associated with long-term potentiation (LTP), and it has been observed that chronic substance use triggers reorganization in the reward system by affecting synaptic plasticity in the brain (Laurent & Kauer, 2019; Monti et al., 2012). This reveals important dynamics that must be considered in terms of both the development of addiction and treatment processes.

Finally, the effects of stress hormones on addiction are also important. Stress triggers dopamine release, and early-life trauma increases the risk of addiction, creating a cyclical model related to addiction. It has been proven that disruptions in the HPA axis increase individuals' susceptibility to addictive behaviors (Cheng et al., 2017; Wang et al., 2012).

11. CONCLUSION

In conclusion, considering the multi-layered origins of addiction, effective and sustainable treatment approaches can only be achieved through a biopsychosocial holistic model. This model ensures that the neurobiological, psychological, and social factors that contribute to addiction are addressed holistically. In particular, understanding the neurobiological foundations and integrating genetic predispositions and impulse control disorders into treatment processes increases the chances of success. Psychologically, developing impulse control and cognitive-emotional functions is critical in combating addiction. Furthermore, not overlooking social and environmental factors is fundamental to creating a personalized and comprehensive intervention environment. In an individual's addiction treatment process, it is crucial to consider individual differences and adopt an approach shaped by these differences. In this context, collaboration between biologists and psychologists facilitates the development and implementation of scientifically based integrated treatment plans. In the future, deepening the integration of neuroscience and psychology will open new horizons in addiction treatment. These advances will increase treatment effectiveness and enable the development of strategies to prevent addiction. Furthermore, by adopting a multidisciplinary approach, solutions best suited to the needs of the patient and their family should be developed. In conclusion, the importance of multidisciplinary approaches in addiction treatment is increasing day by day, and thanks to these approaches, modern and holistic solutions that will increase patients' chances of recovery can be offered. This provides long-term benefits that will both improve individuals' quality of life and improve the overall health of societies.

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