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The digital trap: unraveling the neuropsychological impact of technology addiction

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ABSTRACT

In today's digitally-driven world, technology addiction has become a significant public health issue with serious mental health implications. This review examines the neuropsychological effects of technology addiction, focusing on Internet Gaming Disorder (IGD), Social Media Addiction (SMA), nomophobia, and Fear of Missing Out (FoMO). Although IGD is recognized in the 11th edition of the International Classification of Diseases (ICD-11), technology addiction as a broader category remains unofficial in diagnostic systems like the Diagnostic and Statistical Manual of Mental Disorders (DSM). Findings reveal the involvement of dopaminergic pathways in reinforcing addictive behaviors, brain changes caused by excessive technology use, and impairments in executive functioning, memory, and emotional regulation. Developmental, gender, and cultural factors influencing vulnerability to addiction are also discussed, alongside current therapeutic approaches. The review highlights critical gaps in research and underscores the importance of a nuanced understanding of technology addiction to guide effective psychiatric practice and policy-making.

Keywords: technology addiction; internet gaming disorder; social media addiction; nomophobia; fear of missing out

1. INTRODUCTION

Technology addiction, a relatively new but rapidly growing phenomenon, refers to the compulsive and excessive use of digital devices, applications, and platforms, which leads to significant impairment in daily functioning and mental well-being. While technology has become an integral part of modern life, offering unprecedented access to information, communication, and entertainment, its overuse has been increasingly recognized as a potential behavioral addiction. Unlike substance-related addictions, technology addiction encompasses behavioral dependencies on activities such as online gaming, social media engagement, and compulsive smartphone use. Specific conditions within this category include Internet Gaming Disorder (IGD), Social Media Addiction (SMA), nomophobia (fear of being without a mobile device), and Fear of Missing Out (FoMO) (Sherer & Levounis, 2022). Of these, IGD is formally recognized in the 11th edition of the International Classification of Diseases (ICD-11), while the others remain unofficial but widely studied phenomena.

The prevalence of technology addiction varies widely across populations and regions, affecting a significant portion of the global population. For instance, IGD and SMA have been shown to disproportionately impact adolescents and young adults, with studies reporting that up to 6% of the world's population may be affected by IGD (Kuss et al., 2014). Similarly, excessive smartphone and social media use is prevalent, with some studies estimating that up to 30% of young adults exhibit problematic patterns indicative of SMA or nomophobia (Király et al., 2020). These conditions underscore the need for a nuanced understanding of the broad spectrum of behaviors encompassed by technology addiction and their neuropsychological implications.

The mental health challenges posed by technology addiction are substantial. The compulsive use of digital devices has been linked to a range of psychological issues, including anxiety, depression, and social isolation, as well as cognitive impairments such as reduced attention span and memory dysfunction (Panova & Carbonell, 2018). Furthermore, persistent engagement with technology disrupts sleep patterns and physical health, contributing to a cycle of dependence that is difficult to break. As digital technologies continue to evolve and integrate into everyday life, the risk of addiction – and its associated neuropsychological consequences – is likely to increase.

This review aims to explore the neuropsychological impact of technology addiction by examining the specific conditions of IGD, SMA, nomophobia, and FoMO. It focuses on how excessive use of digital devices and platforms alters brain function, cognition, and behavior. By identifying the underlying

neurobiological mechanisms, cognitive and behavioral outcomes, and associated psychiatric disorders, this review provides a comprehensive overview of the current state of research. Additionally, it seeks to address gaps in the literature and propose directions for future research, particularly in the development of effective interventions and therapeutic approaches.

2. METHODOLOGY

A systematic approach was utilized for this literature review, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a transparent and reproducible process for identifying and selecting relevant studies.

2.1 Search strategy

The search strategy employed specific keywords designed to capture the scope of the review while addressing neuropsychological and behavioral aspects of technology addiction. Keywords included “Technology Addiction”, “Digital Addiction”, “Internet Gaming Disorder”, “Social Media Addiction”, “Nomophobia”, “Fear of Missing Out”, “Neuropsychology”, “Cognitive Impairment”, “Developmental Considerations”, “Gender Differences”, “Cultural Perspectives”, “Psychiatric Disorders”, “Intervention Strategies” and “Treatment Approaches”. These terms were chosen to reflect the multidimensional nature of technology addiction and its implications across various domains, including neuropsychology, cultural and gender influences, and intervention methodologies.

The inclusion of terms like “Digital Addiction” alongside “Technology Addiction” ensured broader coverage of literature addressing related conditions. Additionally, terms such as “Developmental Considerations” and “Cultural Perspectives” were included to capture studies exploring age-specific and cultural dimensions of technology addiction. Keywords related to interventions and treatments, such as “Intervention Strategies” and “Treatment Approaches”, were included to ensure the review addressed therapeutic approaches comprehensively.

2.2 Selection process

The review process involved two independent evaluators who conducted a rigorous screening of articles to minimize bias and ensure reliability. These

evaluators utilized Rayyan, a web-based tool for systematic reviews, to manage and streamline the screening process. Articles were initially screened based on titles and abstracts, followed by a full-text review to confirm alignment with the inclusion criteria. Discrepancies between evaluators were resolved through discussion, ensuring a consensus-based selection of articles.

2.3 Inclusion and exclusion criteria

Studies were included if they met the following criteria:

- Language: published in english
- Focus: specifically addressed technology addiction or its subtypes (IGD, SMA, nomophobia, FoMO)
- Scope: examined neuropsychological, cognitive, or behavioral outcomes related to technology addiction
- Context: included considerations of developmental, cultural, or gender factors or discussed interventions and treatments.

2.4 Bias minimization

Potential biases were addressed by:

- Keyword refinement: broad terms like “Technology Addiction” were supplemented with specific subcategories such as IGD, SMA, nomophobia, and FoMO to ensure a focused search
- Independent review: the use of two independent evaluators reduced the risk of subjective biases during article selection
- PRISMA guidelines: the application of PRISMA guidelines ensured systematic documentation of the selection process, including reasons for exclusion.

2.5 Study selection overview

Initially, 136 articles were retrieved from reputable databases, including PubMed, Google Scholar, Scopus, and Web of Science. After the removal of duplicates, 98 articles remained. These underwent a rigorous screening process, resulting in the selection of 35 articles that met the inclusion criteria.

A PRISMA flow diagram (Figure 1) illustrates the selection process, detailing the number of records identified, screened, and included in the final review, along with reasons for exclusion at each stage.

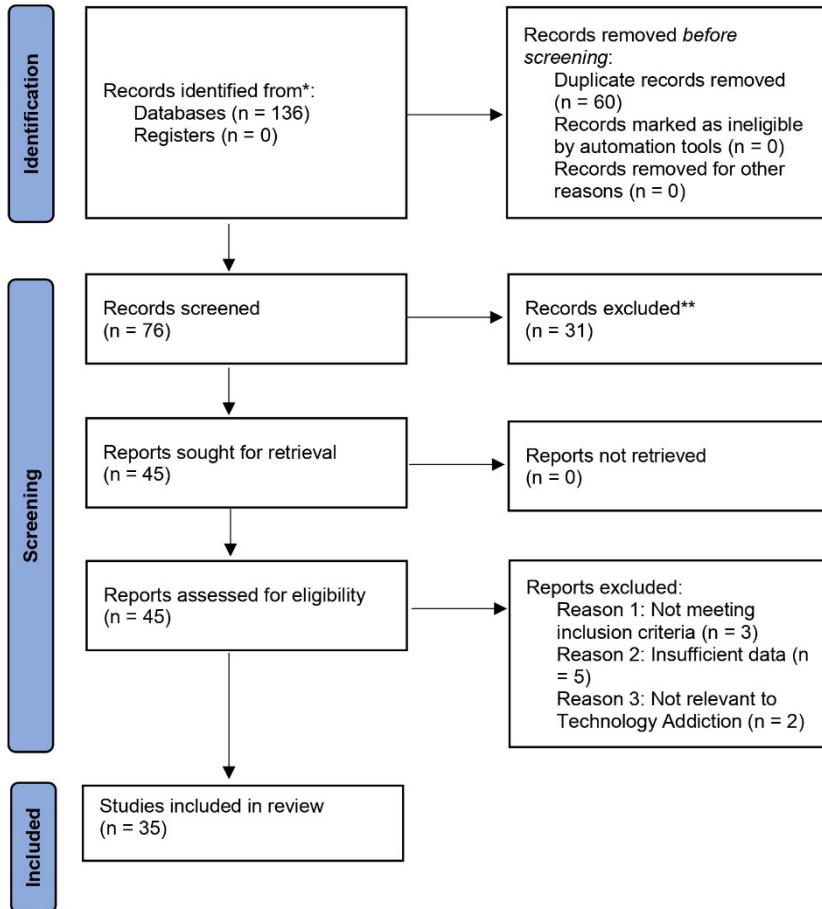


Figure 1. The PRISMA flow diagram

3. THE NEUROBIOLOGY OF TECHNOLOGY ADDICTION

Technology addiction has been increasingly recognized as a significant concern in modern society, with profound neurobiological implications. Central to this is the involvement of dopaminergic pathways, which play a critical role in the brain's reward system. When engaging in activities associated with technology,

such as gaming or social media use, there is a release of dopamine in areas like the ventral striatum, particularly within the nucleus accumbens. This release is closely linked to the sensation of reward and reinforcement, driving compulsive behavior as the brain continuously seeks out the pleasurable experiences associated with technology use (Chen et al., 2017; Hou et al., 2012).

Moreover, dopamine's role in addiction extends beyond mere pleasure. Recent research indicates that dopamine is also involved in reward prediction, where the neurotransmitter's activity increases in anticipation of a reward and decreases when the reward is less than expected. This mechanism may contribute to the compulsive nature of technology use, as individuals persistently seek out experiences that they anticipate will bring satisfaction, even when such satisfaction is not consistently achieved (Berridge & Robinson, 2016; Chen et al., 2017).

In addition to dopamine, other neurotransmitters such as serotonin and norepinephrine also play crucial roles in technology addiction. Serotonin is linked to mood regulation, and imbalances in this neurotransmitter can exacerbate the negative emotional states that drive compulsive technology use. Norepinephrine, associated with arousal and alertness, may further reinforce addictive behaviors by heightening the excitement and engagement experienced during technology use (Berridge & Robinson, 2016; Ebrahimi et al., 2024).

Neuroimaging studies have revealed that chronic technology use can lead to structural and functional changes in the brain. For instance, reductions in gray matter volume have been observed in areas related to executive function, such as the prefrontal cortex, which is critical for decision-making and impulse control. These changes may underline the difficulty that individuals with technology addiction experience in controlling their usage and the persistence of addictive behaviors despite negative consequences (Ebrahimi et al., 2024; Norman et al., 1986). Additionally, alterations in brain connectivity patterns suggest that technology addiction may disrupt the normal communication between brain regions, further compounding the challenges in behavior regulation (Norman et al., 1986).

4. BEHAVIORAL AND COGNITIVE CONSEQUENCES

The behavioral and cognitive consequences of technology addiction have become increasingly concerning, particularly as they impact executive functioning, memory, learning, and emotional regulation.

Executive functioning, which includes processes such as attention, decision-making, and impulse control, is particularly vulnerable to the effects of

excessive technology use. Studies have shown that prolonged exposure to digital media can impair these cognitive processes by disrupting the brain's ability to focus and process information deeply. This is particularly evident in the reduction of sustained attention and the increased susceptibility to distractions, both of which are critical components of executive control. The overuse of technology can lead to what is termed "digital dementia", a condition where cognitive abilities, particularly those related to attention and memory, are diminished due to the constant use of digital devices (Vedechkina & Borgonovi, 2021).

Memory and learning are also significantly affected by the constant connectivity provided by digital devices. The cognitive load imposed by multitasking between different digital platforms can overwhelm the brain's capacity to store and retrieve information efficiently. This constant bombardment of stimuli can lead to shallower information processing, where individuals may retain less information over time. Research suggests that the brain's working memory is compromised, leading to difficulties in forming long-term memories. Moreover, this digital overload can interfere with the consolidation of new information, further hindering learning processes (Neophytou et al., 2021).

Emotional regulation is another critical area impacted by technology addiction. The frequent use of digital devices has been linked to increased levels of anxiety, depression, and overall emotional dysregulation. The instant gratification provided by digital interactions can alter the brain's reward systems, leading to a decreased ability to manage emotions effectively. Over time, this can exacerbate symptoms of anxiety and depression, as individuals may become more reliant on technology for emotional support, rather than developing healthy coping mechanisms. The long-term effects can include a diminished ability to handle stress and an increased likelihood of experiencing mood disorders (Neophytou et al., 2021; Vedechkina & Borgonovi, 2021).

5. PSYCHIATRIC DISORDERS ASSOCIATED WITH TECHNOLOGY ADDICTION

The rapid and pervasive integration of technology into everyday life has contributed to the emergence of several psychiatric disorders, primarily linked to the overuse of digital platforms and the internet. These disorders not only impact mental health but also pose significant challenges in terms of diagnosis, treatment, and prevention. The three most prominent among these are IGD, SMA, and other emerging conditions like nomophobia and FoMO.

IGD has garnered considerable attention and has been officially recognized in the ICD-11 by the World Health Organization (WHO). It is characterized by a persistent and recurrent engagement in gaming, leading to significant impairment or distress in personal, social, and occupational areas of functioning. Diagnostic criteria for IGD include preoccupation with games, withdrawal symptoms when gaming is restricted, and unsuccessful attempts to control gaming habits. These behaviors must be present for at least 12 months to meet the diagnostic threshold (King et al., 2017; Schneider et al., 2017).

The neuropsychological impact of IGD is profound. Research indicates that IGD is associated with altered functioning in the brain's reward system, particularly in regions like the prefrontal cortex and the ventral striatum, which are critical for impulse control and decision-making. These changes can lead to poor executive function, reduced ability to delay gratification, and increased risk-taking behaviors. Neuroimaging studies have shown that individuals with IGD exhibit reduced gray matter volume in areas associated with cognitive control and emotional regulation, which may explain the compulsive nature of gaming and its impact on daily functioning (Dong et al., 2017; Yao et al., 2017).

SMA is increasingly recognized as a major public health concern, particularly among adolescents and young adults. This condition involves the excessive use of social media platforms, characterized by an obsessive need to check and update social media accounts, often at the expense of real-world interactions and responsibilities. The compulsive nature of SMA is driven by the desire for social validation, fear of social exclusion, and the constant need for new content, which can lead to significant mental health issues such as anxiety, depression, and body image disturbances (Moreno et al., 2022).

The relationship between SMA and mental health is complex. Studies have shown that excessive use of social media can lead to increased feelings of loneliness, despite the perception of being connected to others online. This paradoxical effect is thought to result from the superficial nature of online interactions, which may not provide the same emotional fulfillment as face-to-face communication. Furthermore, the constant exposure to idealized images on social media can exacerbate body image issues, particularly among young women, leading to increased rates of eating disorders and low self-esteem (Andreassen et al., 2017; Burén et al., 2023).

In addition to IGD and SMA, other technology-related disorders have begun to emerge, reflecting the evolving nature of digital addiction. nomophobia, or the fear of being without a mobile phone, is one such condition. This disorder is characterized by feelings of anxiety, panic, and discomfort when an individual is separated from their mobile device or when they are unable to access the internet. Nomophobia can lead to significant disruptions in daily life, as individuals may go to great lengths to ensure they

are constantly connected, leading to sleep disturbances, impaired concentration, and increased stress levels (Kato et al., 2020).

FoMO is another emerging condition that has been linked to the compulsive use of social media. FoMO is driven by the anxiety that others are engaging in rewarding activities that one is missing out on, leading to a compulsive need to stay connected and updated on social media platforms. This fear can result in constant checking of social media feeds, even in inappropriate situations, such as during work or social interactions, leading to impaired social and occupational functioning. Over time, FoMO can contribute to feelings of inadequacy, lower life satisfaction, and increased risk of depression (Elhai et al., 2017; Przybylski et al., 2013).

6. DEVELOPMENTAL CONSIDERATIONS

The neuropsychological impact of technology addiction on development is most pronounced during childhood and adolescence, critical periods of brain maturation. Studies show that high levels of screen time in children are linked to reduced gray matter volume in the prefrontal cortex, a region essential for executive functions like decision-making, attention, and impulse control (Sultana et al., 2021). These changes can impair cognitive abilities, including focus, memory retention, and emotional regulation.

Adolescents face heightened vulnerability due to ongoing development in neural circuits governing reward processing and social behaviors. Activities such as gaming and social media overstimulate the brain's dopaminergic pathways, which reinforce compulsive behaviors and contribute to a heightened risk of anxiety and depression (Maza et al., 2023). Additionally, the constant connectivity and rapid information flow associated with digital media can overwhelm cognitive resources, leading to increased cognitive load and diminished capacity to process information effectively (Telzer et al., 2015).

Young adults transitioning into independence may experience long-term consequences from early exposure to technology addiction. Prolonged use during critical developmental windows is associated with persistent structural changes in the brain, potentially leading to chronic difficulties with attention, impulse control, and emotional regulation (Nagata et al., 2022). These changes can have far-reaching impacts on academic and professional performance.

The long-term neuropsychological effects of early and excessive technology use underscore the need for early interventions. Promoting healthy digital habits during childhood and adolescence is crucial for mitigating these risks. Strategies such as limiting screen time, fostering offline activities, and

encouraging parent-mediated interventions can support optimal brain development (National Institute of Mental Health – NIMH, 2024).

7. GENDER AND CULTURAL DIFFERENCES

Gender differences significantly influence patterns of technology addiction. Research reveals that men are more likely to develop IGD, with behaviors linked to competitive, reward-driven activities that activate dopaminergic reward pathways. This predisposition to gaming addiction among men often correlates with increased aggression, social isolation, and symptoms resembling Attention-Deficit Hyperactivity Disorder (ADHD) (Alqarni et al., 2024).

Conversely, women are more susceptible to addiction driven by social media and mobile phone use, which often involves emotional and social dimensions. These behaviors are linked to anxiety, depression, and self-esteem issues stemming from social comparison and body image concerns on platforms like Instagram and Facebook. Women's technology use is also more commonly tied to stress-coping mechanisms, potentially exacerbating compulsive use and psychological distress (Chen et al., 2017; Leow et al., 2023).

Cultural variations further modulate technology use and addiction patterns. In collectivist cultures such as South Korea and China, the emphasis on academic success and social relationships often drives higher rates of internet and social media addiction. For example, adolescents in East Asia are particularly vulnerable to addiction due to societal pressures for academic achievement and online social conformity (Kuss & Lopez-Fernandez, 2016). In individualistic cultures, technology addiction often centers around self-expression and personal achievement, such as content creation and gaming.

Cultural attitudes also shape the perception of technology addiction. In societies that highly value technological advancement, excessive digital use may be normalized, potentially obscuring the negative consequences. Conversely, cultures that stigmatize technology overuse may exacerbate psychological distress among those affected, highlighting the need for culturally tailored interventions.

8. INTERVENTIONS AND TREATMENT APPROACHES

Addressing technology addiction necessitates a multifaceted approach encompassing psychological, behavioral, and emerging pharmacological strategies.

Cognitive-Behavioral Therapy (CBT) remains the most extensively validated intervention for technology addiction. CBT focuses on restructuring maladaptive thought patterns and behaviors associated with excessive technology use. Studies have shown that both traditional face-to-face CBT and computerized CBT (cCBT) effectively reduce compulsive behaviors and improve executive functions, such as decision-making and impulse control (Carroll et al., 2014). Tailored CBT approaches have demonstrated significant efficacy in managing IGD and SMA, particularly when addressing underlying cognitive distortions like perfectionism or FoMO (Carroll et al., 2014).

Mindfulness-based interventions, including Mindfulness-Based Stress Reduction (MBSR), are gaining recognition for their role in technology addiction treatment. These interventions enhance individuals' awareness of their technology-related triggers and reduce automatic, compulsive responses to digital stimuli. Research highlights the efficacy of mindfulness techniques in improving emotional regulation and reducing relapse rates among individuals recovering from technology addiction (Bowen et al., 2009).

Digital detox programs, which promote abstinence from digital devices for defined periods, have shown promise in alleviating the behavioral and neuropsychological impacts of technology addiction. These programs are particularly effective when combined with structured offline activities, enabling participants to reset their digital habits (Bowen et al., 2009).

Pharmacological interventions, while still experimental, are being explored to address co-occurring psychiatric symptoms associated with technology addiction. Selective Serotonin Reuptake Inhibitors (SSRIs), commonly used to treat anxiety and depression, show potential for managing underlying emotional distress contributing to compulsive technology use (Grant et al., 2006). However, the evidence remains inconclusive, necessitating further research to establish the efficacy and safety of such approaches.

Comprehensive intervention strategies should incorporate early prevention efforts, particularly for vulnerable populations like adolescents. Collaborative approaches involving schools, families, and mental health professionals can foster resilience against technology addiction while promoting healthier digital practices.

9. FUTURE DIRECTIONS IN RESEARCH

The landscape of technology addiction is rapidly evolving, necessitating continuous research to understand emerging challenges. One key area for future exploration is the impact of new and advancing technologies, such as Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), on addictive behaviors. These technologies, while offering numerous benefits, also present potential risks for new forms of addiction. For example, the immersive nature of VR and AR could exacerbate the disconnect from reality seen in existing addictions, leading to a deeper entrenchment in digital environments (The future of research: Emerging trends and new directions in scientific inquiry – Research leap, 2023). The integration of AI into daily life, from smart devices to personalized content algorithms, could further perpetuate addictive behaviors by continuously optimizing engagement based on user behavior (Ding et al., 2023).

In addition to these emerging technologies, significant gaps in current research need to be addressed. There is a pressing need for longitudinal studies that explore the long-term effects of technology addiction on neuropsychological health. Most existing research is cross-sectional, providing a snapshot rather than a comprehensive view of how these behaviors evolve and impact individuals over time. Moreover, the interaction between genetic predispositions and environmental factors in technology addiction remains underexplored, warranting further investigation.

Ethical considerations are also critical in the future of technology addiction research. As new technologies are developed, researchers and policymakers must balance the potential benefits with the risks to mental health. Ethical questions arise around the responsibility of technology developers in mitigating addiction risks, particularly in industries where engagement and user retention are prioritized. The use of personal data by AI to tailor experiences that may increase addictive tendencies also raises concerns about consent and the potential for exploitation (The future of research: Emerging trends and new directions in scientific inquiry – Research leap, 2023).

10. CONCLUSION

In conclusion, technology addiction presents a growing neuropsychological challenge, with diverse impacts influenced by demographic and cultural factors, particularly affecting adolescents and children due to their developing neural structures. Compulsive digital use disrupts brain reward systems, cognitive

functions, and emotional regulation. Effective interventions include CBT, mindfulness-based approaches, and structured digital detox programs, while pharmacological treatments remain experimental but promising for co-occurring psychological symptoms. As digital technologies evolve, addressing new addictive behaviors requires a multidisciplinary, culturally sensitive approach, early promotion of healthy practices, and resilience-building. Future research should focus on prevention strategies and ethical considerations to balance innovation with mental health safeguards.

Availability of data and material

Data sharing not applicable to this article as no data-sets were generated or analyzed during the current study.

Competing interests

The authors declare that they have no competing interests.

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