Psychological and Neurobiological Changes in Individuals with Gaming Disorder:

Hidden Vulnerability Factors and Interactions with Other Psychiatric Disorders

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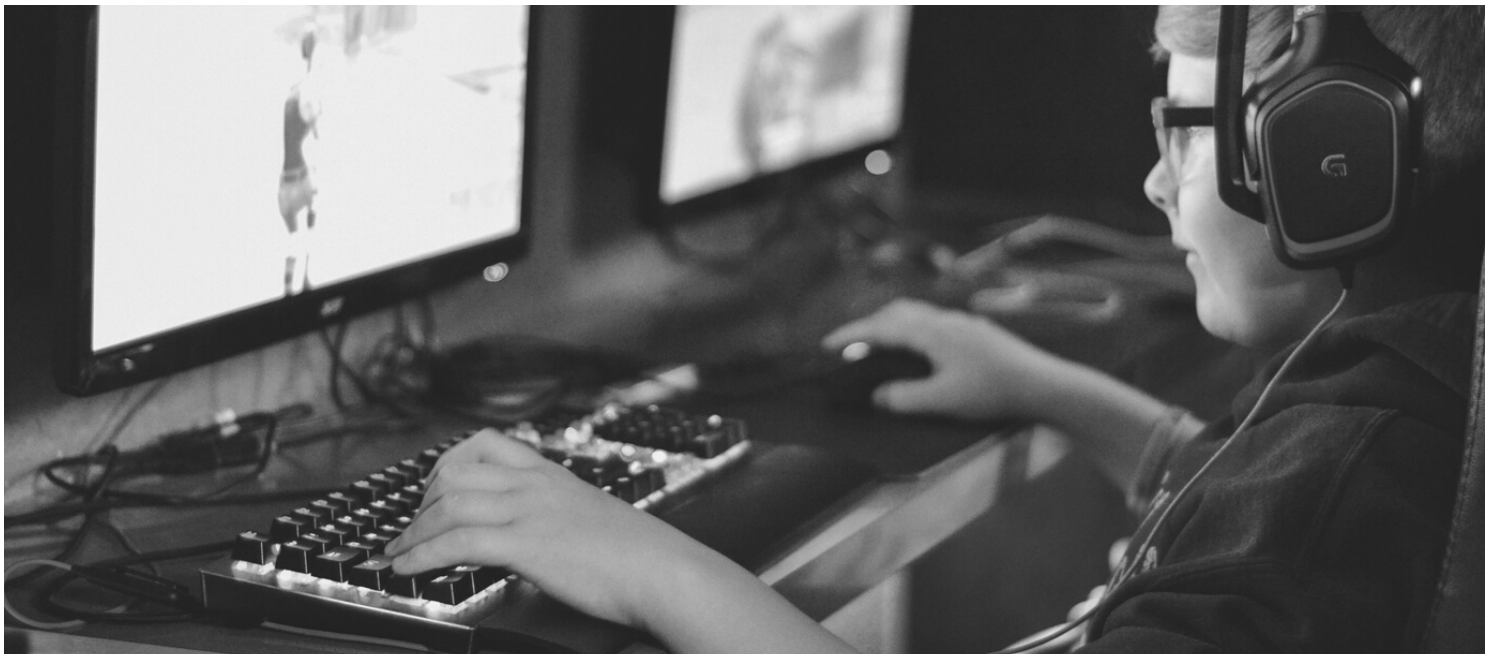

Introduction

Over the last decade, gaming has become one of the most popular leisure activities among not only children and adolescents but also adults. Importantly, epidemiological data indicate that while gaming may contribute to improve visual stimulus encoding and short-term memory [1], in some individuals it may induce **addiction symptoms** and significantly disrupt wellbeing [2]. For example, recent studies [3, 4] have found that engagement in role-playing online games may be linked to an increased risk for an addictive use, recently referred to as **internet gaming disorder (IGD)** [5]. First estimations show that IGD affects 3% of adolescents and 0.2-3.7% of the adult population [6-8]. In some Asian countries these rates have been found to be even higher [9], which has recently been met with **concern by the local mental health policy makers** and tackled in some cases **imposing restrictions** on the total number of weekly hours spent on online gaming websites [10]. However, recent research suggests that **gaming is a form of self-medication** [11] which, in some individuals could become a dysfunctional strategy to cope with stress, frustration, and need for higher levels of stimulation, similarly to what is observed in substance-abuse/addictive behaviors [12]. Thus, knowledge regarding **personality and neurobiological risk factors** could be key to developing syndrome models used within psychotherapy and psychoeducation programs to implement as **alternatives to strict and indiscriminate restriction policies.**

Personality traits and lifestyle characteristics of individuals with gaming disorder

A number of studies have systematically investigated the relationship between personality and gaming disorder. The findings indicate consistent associations with **loneliness, anxiety, shyness and neuroticism** [13-15]. Interestingly, other research has shown that similar personality traits are predictive factors of pathological gambling, suggesting that restriction-based interventions against gaming should be accompanied by campaigns aiming at protecting at-risk populations from engaging in comparably life-disrupting behavior. In this context, Müller et al. [16] have proposed that individuals with a tendency to introversion, neuroticism and poor conscientiousness could be more vulnerable to IGD. In these individuals, the increasingly greater motivation to engage in computer games might be the consequence of their **struggle to function socially**, and could be interpreted as a dysfunctional stress-coping strategy.

Neuropsychological and neurobiological anomalies in IGD

Persons diagnosed with IGD report symptoms that resemble those of substance-related addictions and neuroscientific studies have revealed structural/functional correlates [17]. Of note, **functional magnetic imaging (fMRI)** studies have found **significant neurobiological differences** between healthy individuals and individuals with IGD, suggesting that persons with IGD have worse response-inhibition and emotion regulation, impaired prefrontal activity and cognitive control, poorer working memory and decision-making abilities, impairedvisual and auditory functioning, and disruptions of the neuronal reward system. Importantly, it has been proposed that **these deficiencies are comparable to those found in individuals with substance-abuse**, suggesting that substance-related and behavioral addictions share common symptoms and neurological changes [18, 19].

These findings also appear to be similar to the results of **electroencephalogram (EEG)** studies that can be subdivided in at least three different groups, on the basis of the clinical/behavioral profiles of the patients examined:

1. Excessive and addictive gaming
2. Gaming addiction and other comorbid disorders
3. Gaming addiction (miscellaneous)

Excessive gaming

A study that measured **event related potentials (ERP)** during performance of a Go/NoGo paradigm found that, compared to controls, excessive gamers had reduced fronto-central activity, poor error processing and less inhibition (a measure of impulsivity) on both behavioral and self-reported measures [20]. Other ERP studies found that excessive gaming was associated with enhanced motivation to play, a tolerance effect (habituation), an alteration of normal reward processing [21] and also to dysfunctional information processing [22]. Importantly, EEG measured at rest from individuals with IGD revealed **increased low frequency** (delta and theta) activity when compared to healthy controls, which was normalized 6 months after the administration of an outpatient management program that included the administration of antidepressants [23].

Gaming addiction and other comorbid disorders

Research employing **quantitative EEG (qEEG)** research suggests that individuals with gaming disorder are also often diagnosed with **attention deficit hyperactivity disorder (ADHD)**, which may increase vulnerability to loss of control [24]. Individuals with comorbid ADHD/gaming disorder may exibit **lower relative delta band power** and **higher relative beta band power** in temporal regions, and **greater inter-hemispherical delta band coherence**, when compared to individuals with ADHD only [24]. Interestingly, it has been proposed that individuals vulnerable to ADHD may engage in continuous videogame play to subconsciously improve attention and that brain activity anomalies as measured by **qEEG could provide clues on the interplay between gaming disorders and co-occurring ADHD** [24].

There is also evidence that **IGD may be comorbid with major depressive disorder (MDD)**. In particular, a qEEG study revealed that individuals with IGD and MDD exhibit increased intra- and inter-hemispheric coherence, when compared with individuals with MDD only.

Gaming addiction (miscellaneous)

An ERP study by Peng et al. [25] found that IGD is characterized by impairments in social communication and by the avoidance of social contact. In particular, the behavioral findings showed that individuals with IGD were slower than controls in response to the presentation of either sad or neutral expressions. The ERP results demonstrated participants with IGD exhibited decreased amplitudes for the component N170 (an index of early face processing) in response to neutral expressions compared to happy expressions, which might be due to altered expectancies for positive emotional content [25].

Conclusions

While gaming disorder is a pathophysiology that exhibits several similarities to addiction disorders, other conditions like ADHD and MDD may co-occur complicating the clinical profile. This might suggest that interventions aimed at minimizing the time spent in gaming activities in the hope of reducing its detrimental neurobehavioral effects on the general population should keep into account that restriction policies may not be the solution, as their implementation might increase the risk for the adoption of even more detrimental self-coping strategies. Finally, more vulnerable individuals might need further support and training from mental health specialists in order to find alternative solutions to their often personality-driven psychosocial challenges.

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