Video games, reward system and addictive behavior: a critical review.

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Abstract. Online games have become increasingly popular worldwide, with more than a third of the world's population being gamers, and this number is expected to continue growing. The effects of electronic gaming have been studied for many years, but there is currently greater interest in this market due to the influence of video games on the brain and their potential alterations. Cognition can be affected by video games, including attentional abilities, working memory, and perception. Understanding these effects is important, as video games can be used as a therapeutic approach. However, there is a growing concern about the impact of video gameplay on the mesolimbic pathway, also known as the reward system, which is a dopaminergic pathway that mediates the processing of rewards and the brain's association of different stimuli with a positive or desirable outcome. Brain imaging studies are crucial when investigating morphological changes in the brain. Several studies have used functional magnetic resonance imaging (fMRI) to examine the effects of video games. Changes in gray matter, cerebral blood flow and ventral striatum are the major findings addressed in fMRI studies, and interestingly these changes are related to the reward system. It is important to understand how video games affect the reward system and how they can be used as a therapeutic approach. Understanding these effects is crucial, especially in relation to possible online and pathological gaming addictions, and may help develop strategies to prevent and treat these disorders.

Keywords. Video games, online gaming, reward system, dopamine transmission, neuroscience, addiction, substance use, drug abuse.

1. Introduction

Videogames and online games are rapdly growing forms of leisure activity. Currently, there are an estimated 3.09 billion video game players worldwide and this number is projected to increase by 2024 [1]. Given their widespread popularity, research on video games' impact on brain function and potential effects is beginning to emerge [2, 3].

Research has shown that video gaming can have an impact on cognitive functioning, affecting attentional skills [4], working memory [5] and perception [6]. Understanding these outcomes is crucial because video games have the potential be used in as therapeutic approach [7]. However, one major concern is the impact of video game playing on the mesolimbic pathway, also known as the reward system [2, 8]. This system is associated with feelings of pleasure and motivation, moreover, some studies suggest that excessive video game playing may lead to addiction and other negative consequences [9-11]. Therefore, it is important to explore the potential risks and benefits of video gaming, particularly with regard to the reward system.

The reward system is a dopaminergic pathway that plays a key role in processing of rewards and the brain's association of different stimuli with positive or desirable outcomes [12]. This system is composed of projections of dopamine neurons from the ventral tegmental area to various structures of the limbic system, including striatum and hippocampus [12]. The ventral striatum, which contains the nucleus accumbens, is a critical structure involved in reward processing [13]. Disruption of the reward system can result in a decrease or increase in dopamine transmission, leading to altered reward processing and potentially addictive behaviors [14].

The potential for addictive behavior is a significant concern when it comes to video gaming, as research has linked it to changes in the reward system [15]. Video game playing has been shown to activate the mesolimbic pathway, which is the brain's reward system [8]. This system is also involved in drug addiction, contributing to concerns about the addictive nature of video games and its impact on the reward system [16].

Several studies have previously investigated the effects of video gaming on areas related to the reward system [15, 17, 18]. Interestingly, in drug abuse the reward system is also compromised [16]. Moreover, video game addiction has been associated with psychological distress among adolescents. A study conducted among expatriate adolescents in Saudi Arabia found a positive correlation between video game addiction and psychological distress [19].

These studies highlights the need to further investigate the impact of video game addiction on mental health and well-being, especially in young people who may be more vulnerable to developing addictive behaviors. Therefore, it is important to explore how videogames affect the reward system and if there is a potential addiction process related to it. In this article we will review the effects of online and video gaming in the reward system and whether the resulting alterations are like those caused by substance use.

2. Methodology

To conduct our research we reviewd articles related to video gaming that were published on PubMed (http://www.ncbi.nlm.nih.gov/pubmed/). We used a set of selected keywords, including "video games", "online games" or "video gaming" appearing together with "neural basis", "neuronal pathways", "nervous system", "mesolimbic pathway" or "reward pathway". The studies selected primarily focused on brain imaging data related to neural pathways and brain alterations associated with online gaming. Additionally, we included information on internet gaming disorders in our review.

3. Results and Discussion

Imaging studies are crucial for investigating morphological brain alterations. One of the most valuable imaging methods for studying brain function is functional magnetic resonance imaging (fMRI), which can detect changes in brain mass, blood flow, and activity.

Regarding video games, several studies have utilized fMRI. For instance, studies on cerebral blood flow showed that individuals with internet gaming disorder have higher activity in areas related to a conscious need to use of drugs, such as the insula [20]. Additionally, pathological video game playing have a higher response to attentional bias and cue reactiviity, mechanisms that are also present in substance addiction [21].

Gray matter changes have also been studied using fMRI. In one study, video game players showed changes on gray matter volume in feedback of loss in the Monetary Incentive Delay task [22]. The same group also found that players had a longer decision-making time when answering the Cambrige Gambling test [22]. Interestingly, some studies have found that video games can actually increase gray matter volume [23] and that this increase is positively associated with the lifetime of videogame playing [24, 25].

In the field of addictive behavior, fMRI studies have provided valuable insights into the brain changes associated with pathological video game playing [26]. These studies have shown that individuals with internet gaming disorder exhibit alterations in cerebral blood flow and gray matter volume, particularly in areas related to reward anticipation and drug cravings [27]. Additionally, studies have suggested a relationship between the reward response at the ventral striatum and video gaming, indicating a potential dopaminergic mechanism underlying the addictive properties of video games [28, 29].

The ventral striatum has been commonly addressed in fMRI studies regarding video gaming alterations in the brain. A review article discusses several studies with findings of these changes in internet gaming disorders [26]. Interestingly some of these studies show evidence of shared psychological and neural mechanisms with other types of substance use disorders [28]. Furthermore, higher volume and activation of the ventral striatum was observed during feedback of loss in frequent players [22]. In another study, both control and test group presented a high activation of ventral striatum in response to a non-videogame related reward task, but, interesntingly, after the test group went through a video game training, that same response was only observed in the trained group [8]. This suggest a relationship between the reward response at the striatum and video gaming. The study also discuss that this response was related to the experience of fun during the task, which could be related to dopaminergic transmission at the striatum.

The striatum is an important area studied in drug abuse. Evidence show that dopaminergic projections to nucleus accumbens seem to be crucial for drug reward [30]. Additionally, several studies underlie de involvement of dopaminergic pathways in compulsive drug use, specially related to dopaminergic striatal – thalamic – orbitofrontal circuit [31, 32]. Interestingly, reward anticipation, a common response in gambling [33] had been related to dopaminergic release in this area [27, 34].

4. Conclusion

The reward system, particularly the entral stritatum, is activated when an individual encounters a rewarding stimulus, leading to dopamine release and a feeling of pleasure that motivates them to seek out similar rewards [12]. Similar mechanisms have been observed in substance abuse [30], and we colected evidence that suggest that video gaming may also trigger these mechanisms.

Studies have shown that video gaming can cause various alterations in the brain, particulary in the gray atter and the ventral striatum [26], which is a key component of the reward system [35]. However, investigating these alterations can be challenging due to the complex and diverse nature of video games and the variability of the individuals who play them

Despite these challenges, it is important to understand the effects of video games on the reward system, especially in relation to possible online and pathological gaming addictions. By doing so we can develop strategies to prevent and treat these disorders. Moreover, understanding these effects may also lead to the development of therapeutic approaches that harness the reward system to promote positive changes in individuals with mental health conditions.

In conclusion, the shared alterations between substance abuse and video game playing underscore the importance of investigating the action of video games in the reward system. Further research in this area is needed to fully understand the impact of video gaming on mental health and well-being, and to develop effective interventions that mitigate any negative effects.

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