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Assessment of Attentional Bias in Internet Gaming Disorder Using the Addiction Stroop Task and Event-Related Potentials

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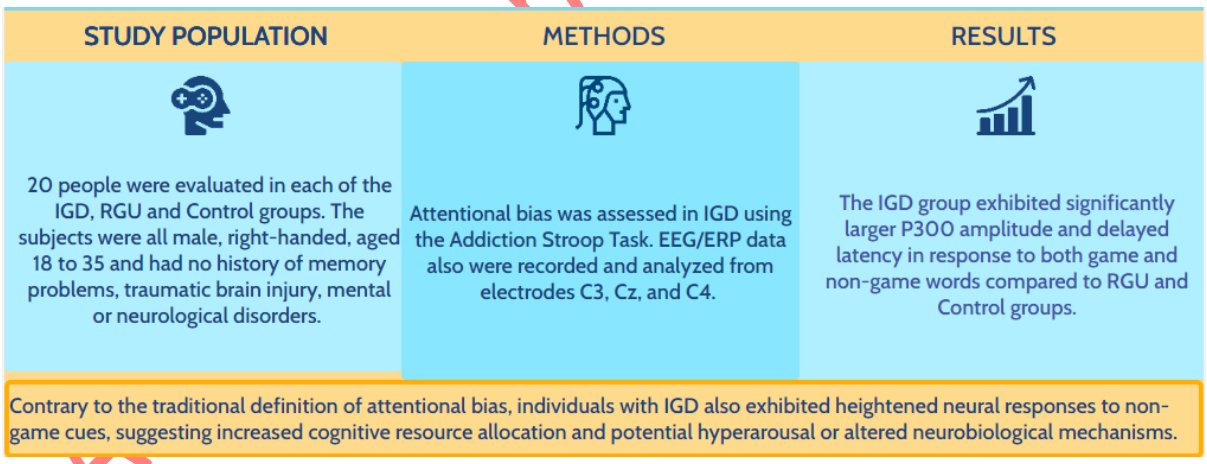
Abstract

Background: Internet Gaming Disorder (IGD) is characterized by impaired control over gaming behavior, prioritizing gaming over other activities and continued gaming despite negative consequences. IGD is a growing concern, impacting individuals' daily lives. Understanding attentional biases in IGD is critical for effective intervention strategies. **Methods:** Attentional bias was assessed in IGD using the Addiction Stroop Task. Participants were divided into three groups: IGD, Recreational Game Users (RGU), and Controls. EEG/ERP data also were recorded and analyzed from electrodes C3, Cz, and C4. **Results:** The IGD group exhibited significantly larger P300 amplitude and delayed latency in response to both game and non-game words compared to RGU and Control groups. Also, impulsivity, anxiety and depression levels were significantly higher in the IGD group compared to the RGU and Control groups. **Conclusion:** In contrast to the traditional definition of attentional bias, which usually involves a preference for addiction-related cues, individuals with IGD exhibited heightened neural responses to both game and non-game cues, suggesting increased cognitive resource allocation and potential hyperarousal or altered neurobiological mechanisms.

KEYWORDS

ERP, attentional bias, addiction stroop task, internet gaming disorder, recreational game users

Figure 1. Graphical abstract of the study. IGD: internet gaming disorder, RGU: recreational game use EEG: electroencephalography, ERP: event-related potentials



INTRODUCTION

The disorder known as Internet Gaming Disorder (IGD) is defined by frequent and continuous online gaming that causes severe impairment or distress. IGD was added by the American

Psychiatric Association (APA) to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) in its fifth edition as a disease that needs more research(1). In the eleventh revision of the International Classification of Diseases (ICD-11), Gaming Disorder (2) was also recognized by the World Health Organization (WHO) as a new diagnosis(3, 4).

The DSM-5 lists the following as diagnostic criteria for IGD:

- Preoccupation with gaming;

- Withdrawal symptoms when gaming is stopped;

- Inability to control gaming participation, leading to an increased need to game;

- Loss of interest in hobbies and entertainment due to, and exclusive to, gaming;

- Continued excessive use of gaming despite knowledge of psychosocial problems;

- Has lied to family, therapists, or other people about the amount of gaming;

- Use of gaming to escape or relieve a negative mood;

- Has jeopardized or lost a significant relationship, job, educational opportunity, or career because of gaming(1).

Similar ICD-11 criteria are used for IGD; these include decreased ability to manage one's gaming, prioritizing gaming over other hobbies and everyday activities, and continuing or increasing gaming even after negative effects have occurred(3, 4).

As IGD does not require a chemical intake, unlike substance addictions, it has been conceptualized as a behavioral addiction(5-10). Consistent with this classification, IGD has demonstrated neurological shared characteristics between substance use and gambling-related issues(11-15). Research has identified several factors that may contribute to the development of IGD, including attention-deficit/hyperactivity disorder (ADHD), obsessive-compulsive

disorder (OCD), anxiety and depression, social anxiety, low self-esteem, interpersonal competence, relationship problems, hostile family environment, social skill deficits, suicidality, and aggressive behaviors(16).

The prevalence of IGD varies depending on the population studied and the criteria used to define the disorder. A meta-analysis of studies on IGD prevalence among adolescents found a pooled prevalence of 4.6%, with male adolescents reporting a higher prevalence rate of 6.8% compared to female adolescents at 1.3% (17). The lack of agreement in the diagnosis of IGD, together with variations in the use of tools, diagnostic procedures, and management strategies, has been linked to the variation in prevalence(18).

Studying gaming at different levels, such as IGD and recreational game use (RGU) groups, is vital. When assessing RGU, it is useful to consider the recreational levels of other potentially addictive behaviors, such as the use of drugs and gambling. Addicts in groups have not always exhibited the same traits as recreational drug or gambling users. Recreational cocaine users have shown less discounting of delayed rewards than individuals with cocaine dependence(19), indicating a comparatively lower level of impulsivity among recreational users. Recreational cocaine users showed different activation patterns during a drug Stroop task compared to cocaine-dependent users. They showed less activation in the anterior cingulate cortex and orbitofrontal cortex than both dependent users and control subjects(20). These findings contrasted with the findings of another study that found recreational cocaine users to exhibit drug-related attentional biases. Recreational users exhibit behavioral and neurocognitive responses that fall somewhere between those of stimulant-dependent and non-using individuals. Research on recreational gambling has found connections between gambling and psychopathology that lie in the middle between issue compulsive gambling and non-/low-frequency gambling(21-24), indicating that subsyndromal levels of gambling may be linked to health problems. While people with RGU might exhibit traits that are halfway between those

with IGD and the Control group, they might also exhibit traits similar to or unique to each group. When compared to the IGD group, individuals with RGU may, for example, have better self-control and similar desire patterns to play games than the Control group. Consequently, unlike the IGD and Control group, behavioral control and reward/loss processes are crucial to understanding RGU(25).

individuals with RGU can play online games regularly without getting addicted or feeling out of control. This is supported by a study that found that although Internet games have been proven to be addictive, only a few game players develop online gaming addiction(2). Additionally, another study suggested that IGD subjects were unable to suppress their gaming cravings after unexpectedly forced breaks, which could explain why RGU subjects can play without feeling out of control(26).

Studies revealed that attentional bias plays a significant role in addiction and influences people's desire to take substances that are addictive. According to several addiction theories, addictive behavior is characterized by an attentional bias towards stimuli associated with substances(27, 28).

Measuring attentional bias toward stimuli relevant to substances may also be a useful tool for identifying people who are more likely to relapse(29). Many studies have examined the impact of substance-related stimuli (verbally, visually, or through in-vivo exposures) on attention in people who use a range of drugs, such as cocaine, alcohol, nicotine, cannabis, opioids, and alcohol throughout the past two decades(30, 31). Similar findings were observed about behavioral addictions, with IGD participants exhibiting longer reaction times than the control group. This indicates that addiction is detected by employing the attentional bias of the IGD subject(32). Attentional bias in IGD is associated with alterations in brain activity, functional connectivity, and cognitive processes. Understanding these relationships is critical for

unraveling the mechanisms underlying IGD and developing effective interventions to address this disorder. Accordingly, we went one step further and decided to investigate the electrophysiological effects of IGD on the brain using EEG and ERPs.

ERPs represent measured brain responses resulting directly from specific sensory, cognitive, or motor events(33). ERPs are extracted from the EEG, a noninvasive technique that records electrical brain activity using scalp electrodes(33).

P300 is an ERP waveform that is typically characterized by a positive peak in the brain's electrical activity around 300 milliseconds after the onset of the stimulus, and it is thought to reflect the brain's cognitive processing of the stimulus, including the allocation of attentional resources and the updating of working memory(34).

Our study aimed to explore attentional bias in individuals with IGD, RGU and a Control group of non-gamers by employing the Addiction Stroop task. We hypothesized that individuals with IGD show a more substantial attentional bias toward gaming-related cues compared to RGU and the Control groups. We also hypothesized that the P300 component, differs between the three groups, with IGD participants showing a larger amplitude of this component compared to RGU and the Control groups. Our study will provide insights into the cognitive mechanisms underlying IGD and potential neural correlates and into account the possible influence of anxiety, depression, and impulsivity, which often accompany IGD.

METHODS

Participants

To find participants, advertising was done on social networks and 20 people were evaluated in each of the IGD, RGU and Control groups. The subjects were all male, right-handed, aged 18 to 35, with no discernible age differences between the three groups. Those with a history of memory issues, traumatic brain injury, mental or neurological illnesses, use of psychiatric drugs, or abuse of drugs or alcohol (aside from cigarette smoking) were excluded from the study. Participants were told to stop smoking three hours before the experiment to diminish the effect of nicotine on brain output(35).

IGD was identified based on meeting the suggested 9-item IGD diagnosis per DSM-5 criteria(36) and receiving a score of 50 or higher on Young's(VAT) online Internet addiction test(37, 38).

Questionnaires

The IGD9-SF (Internet Gaming Disorder Scale-Short Form) is a widely used questionnaire to assess IGD among individuals. It is a shortened version of the full IGD scale and consists of nine items that evaluate the symptoms of IGD, such as loss of control over gaming, preoccupation with gaming, and neglect of other activities due to gaming(39). Young's Internet Use Disorder Assessment(37) consists of twenty items that assess problematic Internet use, including withdrawal, obsessive use, psychological dependence, challenges at work or school, sleep, family, and time management(42).

The use of both IGD and VAT questionnaires in gaming addiction studies is supported by a range of research. The VAT is a reliable and valid tool for measuring video game addiction(40), while studies have also identified significant neurobiological differences in individuals with IGD(41). However, the validity of IGD criteria has been questioned, with some studies finding that they fail to discriminate between healthy gamers and those endorsing IGD criteria(42).

This suggests that the use of both questionnaires allows for a more comprehensive understanding of gaming addiction, taking into account both subjective experiences and neurobiological factors.

Four self-reported questionnaires were also given to the participants to complete: the Edinburg Inventory(43), the Beck Depression Inventory (BDI) (44), the Beck Anxiety Inventory(10) (45), and the Barratt Impulsiveness Scale 11 (BIS-11) (46).

The RGU group is defined and chosen according to these criteria: First, RGU patients should meet less than four of the DSM-5 recommended criteria for IGD, have few disruptions in their everyday lives, and have an IAT score of less than 50. Second, before exhibiting any symptoms of mental or physical dependency, RGU participants had to have played online games for at least two years. Third, to be considered frequent users, RGU members must play online games at least five days a week. Fourth, to be considered frequent users, RGU individuals must play online games for more than 14 hours a week, or more than two hours a day on average. They shouldn't feel any compulsion to play online games at the same time. Furthermore, recreational players shouldn't feel bad or regret their decisions to play online games because their regular usage doesn't conflict with their commitments to their families, friends, jobs, or social responsibilities(25).

Experimental task

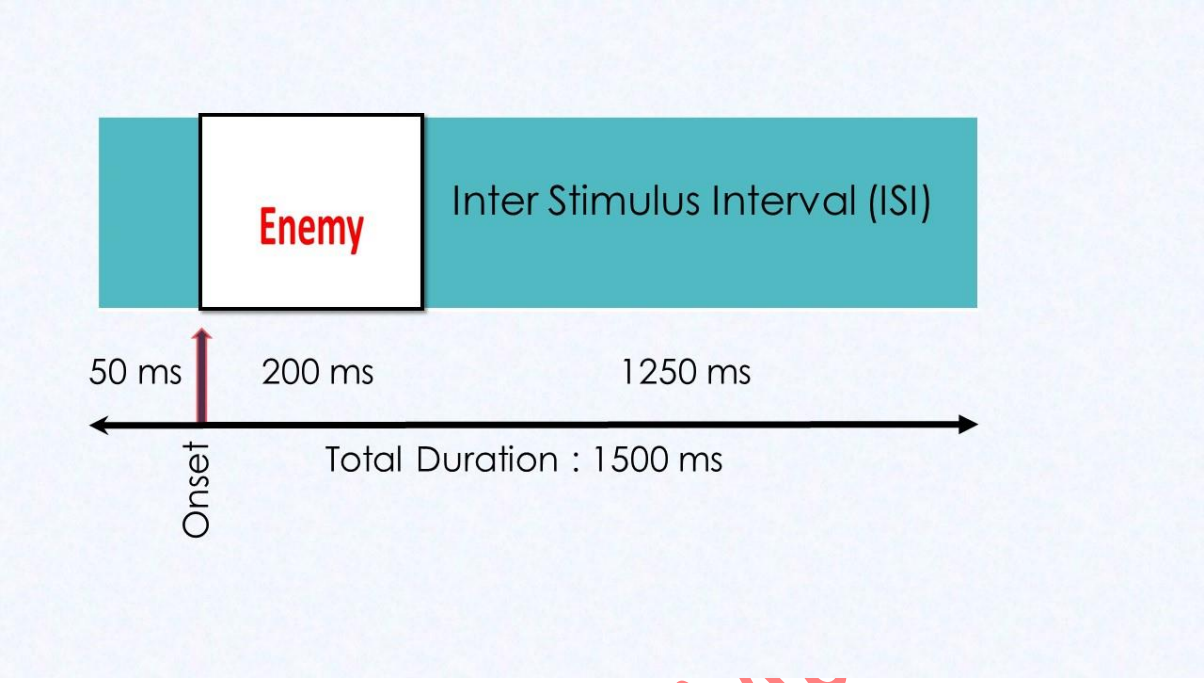
Several paradigms, like the Addiction Stroop task, have been created to test attentional bias toward stimuli associated with substances(47), So a game-related Addiction Stroop task was used. Words were presented in red, green, and blue at random. There were twenty words related to online gaming and twenty matched control words (matched in terms of semantic properties that affect reading speed, such as word length and number of syllables per word). Additionally, to regulate the degree of word familiarity between the two groups, before the study, individuals who had never played online action games like "Call of Duty" and those who had played were

asked to rate their level of word familiarity (they were not included in the study). Accordingly, there is no distinction in the degree of familiarity with "neutral and gaming-related words used in this study. The neutral phrases were selected by pairing the names of common tools, supplies, and gaming-related categories, such as Enemy-Energy.

In the Addiction Stroop task, participants will see control words (blue, red, and green) printed in English using the "Times New Roman" font on a computer screen along with colored targets and a visual angle of approximately 2.5°(48). Every colored word can be printed in two incongruent colors (green and blue, for example) or in a color-congruent ink (red printed with red). People are supposed to react to the color of the ink, not the word's meaning or content. Using their right fingers, they will press one of the three keyboard keys corresponding to the ink's color: Keyboard(KBD)-LEFT = red, KBD-RIGHT = blue, and KBD-DOWN = green.

Each trial of the Addiction Stroop test, lasts 1500 ms, with 1250 ms for the ISI and 200 ms for the stimulus (Figure 2.). The subject must react to the stimulus in 100–1000 ms to receive a valid response. There are 360 trials in the Addiction Stroop test, with a 50/50 ratio of congruent to incongruent trials. To determine which key corresponds with which color, participants practiced 63 trials (21 trials for each color) of five X(XXXXX)) colors in succession before taking the Addiction Stroop test. The behavioral factors examined in the Addiction Stroop task include reaction times in congruent and incongruent trials and accuracy rates in responding to congruent and incongruent trials.

Figure2.The timeline of the Addiction Stroop task. (Enemy: a game-related word in red print)



ERP acquisition

A 32-channel Win EEG system (version 2.126.97, Mitsar Inc.) was used to record and analyze EEG. In order to detect eye movement noise, two electrooculogram (EOG) electrodes were placed beneath the right eye and the right temporal region of the head. The electrode placement was done by the 10–20 system placement standards. 500 Hz was the sample frequency. Electrode impedances were kept below 5 kΩ, and low and high pass filters were adjusted between 0.1 and 30 Hz. The EEG was calculated with Win EEG software utilizing input signals referenced to the connected ear, and it was recorded in a monopolar montage(35). The following procedure was used when performing artifact correction: 1. High-amplitude and high-frequency noises were visually examined in the raw EEG, and noisy trials (more than 100 μv) were rejected; 2. The activation curves corresponding to eye blinks were zeroed to account for eye blink artifacts; 3. The components linked to muscle noise and eye movement were found using Analysis of Independent Components(37, 49). The following time window for the

Addiction Stroop task was identified: 250–450 ms, associated with the P300 Stroop effects well described in the literature(50).

Procedure Assessment

During the EEG recording, participants were seated in a dimly lit, sound-attenuated room that complied with ANSI S3.1-1999 standards. Before the completion of the Addiction Stroop task, they completed the mentioned questionnaires. The participants took a comfortable chair, rested in a relaxed posture, and fixed their heads on their chins. A 17-inch monitor screen was placed one meter away from the participants. Psytask version 1.53.17 of the Russian company Mitsar Inc. was used(35). Every participant signed an informed consent form in writing. EEG is a safe and non-invasive procedure, that causes no harm to participants. The study was approved by the Kerman University of Medical Sciences ethics committee (Ethics Code: IR.KMU.AH.REC.1400.239).

STATISTICAL ANALYSIS

The normality of the data was initially determined using the Kolomogrov-Smirnov test. Once this was confirmed, parametric tests were applied. The demographic and psychometric data of the IGD, RGU, and Control groups were compared using the independent samples t-test. We used two within-subject factors for our ERP analysis: (i) trial type (game, non-game, trials) and (ii) electrode sites (Cz, C3, and C4). We ran a one-way repeated measures ANOVA. The Statistical Package for the Social Sciences (SPSS) software, version 26, was used for all of the analyses.

RESULTS

Demographic and Psychometric Outcomes:

Tables 1 and 2 display the clinical and demographic traits of the research subjects. The findings indicated that there was no discernible age or educational difference between the three groups. The three groups' scores on the BDI, BAI, and BIS showed a substantial variation. Comparing the IGD group to the RGU group, the IGD group spent much more time and days playing online games and had significantly higher scores in VAT and IGD9.

Table 1.

Demographic data of the study participants. the data is presented in MEAN ± SD. (N/A: not applicable). the statistical significance level is p<.05

Variable	IGD	RGU	Control	p value
Age (years)	21.3 ± 3.14	20.85± 1.93	22.44±2.57	<.43
Education(years)	15.33 ± 3.15	16.03 ± 2.94	16.41 ± 3.21	<.33
IGD9	3.5±0.69	2.42±0.48	N/A	<.001
VAT	3.45±0.42	2.57±0.44	N/A	<.001
Day/Week	6.43±0.51	2.51±1.97	N/A	<.000***
Hours/Day	5.83±1.17	1.27±1.08	N/A	<.000***

No significant differences were found in the age and level of education of the participants in the three groups. However, the IGD and VAT test scores were significantly higher in the IGD group than in the RGU group

Table 2.

Psychometric data of the participants. the data is presented as a p-value. the statistical significance level is p<.05

Groups	BIS-II(p-value)	BDI(p-value)	BAI(p-value)
Control vs IGD	<.000	<.000	<.038
Control vs RGU	<.006	<.34	<.82
IGD vs RGU	<.064	<.000	<.022

The levels of depression, anxiety, and impulsivity were significantly higher in the IGD group compared to the RGU and Control groups.

Electrophysiological Data

The analysis of the P300 ERP component in the IGD group revealed significant differences in both amplitude and latency when compared to the RGU and Control groups. The heightened P300 amplitudes and delayed latencies were observed in response to both game and non-game stimuli. Here we examine the results obtained from the amplitude

based on the location of the electrodes, word categories, and groups in more detail in Tables 3 and 4(Amplitude and Latency, respectively).

Table 3.

Comparison of P300 ERP wave Amplitude in IGD, RGU, and control groups in 3 electrodes C3, Cz, and C4. RNG (Red Non-Game-Related Word), BNG (Blue Non-Game-Related Word), GNG (Green Non-Game-Related Word), RG (Red Game-Related Word), BNG (Blue Game-Related Word), GNG (Green Game-Related Word). the data is presented as a p-value. the statistical significance level is p<.05

Groups	Electrodes	RG(p-value)	BG(p-value)	GG(p-value)	RNG(p-value)	BNG(p-value)	GNG(p-value)
	F3	<.218	<.718	<.005	<.001	<.002	<.001
Control VS RGU	Fz	<.092	<.094	<.268	<.829	<.051	<.020
	F4	<.001	<.220	<.002	<.736	<.975	<.823
	F3	<.001	<.001	<.001	<.001	<.008	<.001
Control VS IGD	Fz	<.005	<.001	<.001	<.011	<.001	<.858
	F4	<.176	<.001	<.001	<.001	<.277	<.008
	F3	<.038	<.001	<.001	<.051	<.866	<.790
RGU VS IGD	Fz	<.001	<.069	<.001	<.051	<.414	<.072
	F4	<.001	<.001	<.001	<.001	<.191	<.037

Briefly, heightened P300 amplitudes were observed in the IGD group compared to the RGU and Control groups in response to both game and non-game stimuli.

Table 4.

Comparison of P300 ERP wave Latency in IGD, RGU, and control groups in 3 electrodes C3, Cz, and C4. RNG (Red Non-Game-Related Word), BNG (Blue Non-Game-Related Word), GNG (Green Non-Game-Related Word), RG (Red Game-Related Word), BNG (Blue Game-Related Word), GNG (Green Game-Related Word). the data is presented as a p-value. the statistical significance level is p<.05

Groups	Electrodes	RG(p-value)	BG(p-value)	GG(p-value)	RNG(p-value)	BNG(p-value)	GNG(p-value)
	F3	<.0001	<.495	<.002	<.001	<0.18	<.068
Control VS RGU	Fz	<.039	<.344	<.021	<.001	<.001	<.342
	F4	<.003	<.0001	<.001	<.001	<.001	<.722
	F3	<.001	<.001	<.001	<.001	<.001	<.001
Control VS IGD	Fz	<.001	<.001	<.001	<.001	<.001	<.001
	F4	<.001	<.001	<.001	<.001	<.001	<.001
	F3	<.001	<.001	<.001	<.001	<.001	<.001
RGU VS IGD	Fz	<.001	<.001	<.001	<.001	<.001	<.001
	F4	<.001	<.001	<.001	<.001	<.001	<.001

Briefly, delayed P300 latencies were observed in the IGD group compared to the RGU and Control groups in response to both game and non-game stimuli.

Discussion

This study adds to the expanding literature on IGD by offering empirical evidence of attentional bias using the Addiction Stroop task, which is further supported by ERP measurements. Our findings reveal that individuals with IGD display significantly larger P300 amplitudes and delayed latencies in response to both game-related and non-game words, compared to the RGU and Control groups, indicating a pervasive impairment of attentional control mechanisms.

The increased P300 amplitude observed in the IGD group aligns with previous findings that associate heightened P300 responses with the allocation of attentional resources towards emotionally salient stimuli(50). This is particularly relevant in the context of IGD, where gaming-related cues are likely to hold significant emotional relevance.

The delayed P300 latency further supports the notion that individuals with IGD have difficulty disengaging from gaming-related cues, a finding that echoes the results of studies that have characterized the neural substrates critical to IGD(51).

According to a Chinese study, in the group of individuals with online game addiction, cues related to online games elicited significantly larger amplitudes of P300 than neutral words; however, in the group of casual online gamers, there was no significant difference in the amplitudes between cues related to online game related words and neutral words(52).

Moreover, the elevated levels of impulsivity, anxiety and depression in the IGD group compared to RGU and Control groups are consistent with literature that has established a positive association between these psychological traits and IGD(53).

In explaining why, contrary to previous studies, IGD in addition to game-related stimuli, showed significantly larger P300 amplitudes and delayed latencies in response to non-game-related stimuli, two possibilities can be suggested: hyperarousal and change of neurobiological mechanisms:

Hyperarousal is a common characteristic observed in individuals with addictive disorders, including IGD. Studies have shown that individuals with IGD frequently demonstrate increased P300, which is often associated with impaired excessive allocation of attentional resources toward game-related stimuli (54, 55) For this reason, the increased amplitude and delayed latency of the P300 towards non-game-related cues may be due to hyperarousal(56).

Attentional bias plays a significant role in decision-making processes by influencing the way individuals process and respond to different stimuli. It can lead to a biased allocation of attention towards certain information, which in turn affects the choices made by the individual. This bias can manifest in various ways, including:

1. Neural Mechanisms: Attentional bias is regulated by neural systems, such as the amygdala and The dorsolateral prefrontal cortex (DLPFC). Stimulation of the left DLPFC has been shown to reduce attentional bias towards intergroup threat, highlighting the potential for neural interventions to modify attentional bias and improve decision-making(57).

2. Emotional Processing: Attentional bias towards certain stimuli can also influence emotional processing. For example, in the context of intergroup threat, attentional bias towards negative information can amplify emotional responses, such as anxiety, which can further skew decision-making (57).

3. Cognitive Processing: Attentional bias can also impact cognitive processes, such as memory and perception. For instance, in the context of decision-making under uncertainty, attentional bias towards certain information can influence how individuals perceive and recall different options, potentially leading to different choices (58).

4. Reward Responsiveness: Attentional bias can also be linked to reward responsiveness, which is critical in decision-making. For example, in the context of addiction, attentional bias toward cues associated with the addictive substance can drive behavior toward seeking the substance, even when it is not in the individual's best interest (59).

5. Selective Attention: Attentional bias can cause individuals to focus more on certain aspects of a situation, such as the potential risks or benefits, over others. This selective attention can lead to a skewed perception of the available options, potentially resulting in suboptimal decisions (58).

Attentional bias and P300 ERP play crucial roles in addiction research. Studies on abstinent heroin addicts (AHAs) displayed hypersensitivity to reward-related stimuli, showing weaker attentional control compared to healthy controls(60). In Internet addiction (IA), high-IAT individuals exhibited specific responses to IA-related cues, with decreased feedback-related negativity(FRN), a negative-going component of the ERP that typically occurs between 200 to 300 ms after the onset of feedback stimuli(61, 62) which is believed to reflect prediction error (PE) signals(63), and increased P300, suggesting reward and attentional biases(64). Furthermore, heroin addicts showed differences in P100, P200, N200, and P300 ERPs when processing heroin-related cues compared to controls, indicating altered attentional processing in addiction(65). These findings collectively highlight the intricate relationship between attentional bias and P300 ERP in various forms of behavioral addiction like IGD.

The Addiction Stroop task is a valuable tool in addiction research for measuring attentional bias toward substance-related stimuli. Studies have shown that individuals with various addictions, such as methamphetamine (MA) abusers with or without psychosis, internet addiction disorder (IAD) participants, and abstinent smokers prone to relapse, exhibit distinct patterns in ERPs during the addiction Stroop task. These ERP changes include alterations in components like N200, P300, N450, and late positive potential (LPP), reflecting differences in cognitive processing and cue reactivity(50, 66, 67).

Future research should aim to replicate these results in larger, more diverse populations. Additionally, longitudinal studies are needed to determine the causality and directionality of the relationship between attentional bias and IGD. By focusing on the cognitive and emotional aspects of IGD, we can move towards more effective intervention strategies that not only treat the symptoms but also address the root causes of the disorder.

Conclusion

In contrast to the traditional definition of attentional bias, which usually involves a preference for addiction-related cues, the IGD group exhibited significantly larger P300 amplitude and more delayed latency towards both game and non-game cues in comparison to RGU and Control groups. it does suggest that individuals with IGD allocate more cognitive resources to processing both types of stimuli. This heightened neural response could be indicative of hyperarousal or altered neurobiological mechanisms in IGD.

Declaration of Interest

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Conflict of Interest Statement

The authors have no relevant financial or non-financial interests to disclose.

Authors Contribution Statement

S.M: Study design; analysis; writing the original draft.

A.M.P: Methodology, study design; task design; editing. rewriting

M.N.E: ERP analysis; methodology; rewriting draft.

M.F: Software investigation. Review and editing

M.T.M: Data analysis.

Ethical Consideration Statement

The study was approved by the Kerman University of Medical Sciences ethics committee (Ethics Code: IR.KMU.AH.REC.1400.239).

Funding Statement

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Data Availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions (e.g., they are containing information that could compromise the privacy of research participants).

1. Gentile DA, Bailey K, Bavelier D, Brockmyer JF, Cash H, Coyne SM, et al. Internet Gaming Disorder in Children and Adolescents. Pediatrics. 2017;140(Suppl 2):S81-s5.
2. Wang Y, Wu L, Wang L, Zhang Y, Du X, Dong G. Impaired decision-making and impulse control in internet gaming addicts: Evidence from the comparison with recreational internet game users. Addiction Biology. 2017;22(6):1610-21.
3. Higuchi S, Nakayama H, Matsuzaki T, Mihara S, Kitayuguchi T. Application of the eleventh revision of the International Classification of Diseases gaming disorder criteria to treatment-seeking patients: Comparison with the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders Internet gaming disorder criteria. J Behav Addict. 2021;10(1):149-58.
4. Zhou X, Wu R, Liu C, Kou J, Chen Y, Pontes HM, et al. Higher levels of (Internet) Gaming Disorder symptoms according to the WHO and APA frameworks associate with lower striatal volume. J Behav Addict. 2020;9(3):598-605.
5. Dong G, Potenza MN. A cognitive-behavioral model of Internet gaming disorder: theoretical underpinnings and clinical implications. J Psychiatr Res. 2014;58:7-11.
6. Dong G, Potenza MN. Risk-taking and risky decision-making in Internet gaming disorder: Implications regarding online gaming in the setting of negative consequences. J Psychiatr Res. 2016;73:1-8.
7. Dowling NA. Issues raised by the DSM-5 internet gaming disorder classification and proposed diagnostic criteria. Addiction. 2014;109(9):1408-9.
8. Petry NM, O'Brien CP. Internet gaming disorder and the DSM-5. Addiction. 2013;108(7):1186-7.
9. Petry NM, Rehbein F, Ko CH, O'Brien CP. Internet Gaming Disorder in the DSM-5. Curr Psychiatry Rep. 2015;17(9):72.
10. Rehbein F, Kliem S, Baier D, Mößle T, Petry NM. Prevalence of Internet gaming disorder in German adolescents: diagnostic contribution of the nine DSM-5 criteria in a state-wide representative sample. Addiction. 2015;110(5):842-51.

11. Jorgenson AG, Hsiao RC, Yen CF. Internet Addiction and Other Behavioral Addictions. Child Adolesc Psychiatr Clin N Am. 2016;25(3):509-20.
12. Kuss DJ, Lopez-Fernandez O. Internet addiction and problematic Internet use: A systematic review of clinical research. World J Psychiatry. 2016;6(1):143-76.
13. Liu L, Yip SW, Zhang JT, Wang LJ, Shen ZJ, Liu B, et al. Activation of the ventral and dorsal striatum during cue reactivity in Internet gaming disorder. Addict Biol. 2017;22(3):791-801.
14. Park M, Choi JS, Park SM, Lee JY, Jung HY, Sohn BK, et al. Dysfunctional information processing during an auditory event-related potential task in individuals with Internet gaming disorder. Transl Psychiatry. 2016;6(1):e721.
15. Yuan K, Yu D, Cai C, Feng D, Li Y, Bi Y, et al. Frontostriatal circuits, resting state functional connectivity and cognitive control in internet gaming disorder. Addict Biol. 2017;22(3):813-22.
16. Byeon G, Jo SJ, Park JI, Jeong H, Lee HK, Yim HW. Risk factors and outcomes of internet gaming disorder identified in Korean prospective adolescent cohort study. J Behav Addict. 2022;11(4):1035-43.
17. Fam JY. Prevalence of internet gaming disorder in adolescents: A meta-analysis across three decades. Scand J Psychol. 2018;59(5):524-31.
18. Chiang CLL, Zhang MWB, Ho RCM. Prevalence of Internet Gaming Disorder in Medical Students: A Meta-Analysis. Frontiers in Psychiatry. 2022;12.
19. Hulka LM, Eisenegger C, Preller KH, Vonmoos M, Jenni D, Bendrick K, et al. Altered social and non-social decision-making in recreational and dependent cocaine users. Psychol Med. 2014;44(5):1015-28.
20. Smith DG, Simon Jones P, Bullmore ET, Robbins TW, Ersche KD. Enhanced orbitofrontal cortex function and lack of attentional bias to cocaine cues in recreational stimulant users. Biol Psychiatry. 2014;75(2):124-31.
21. Desai RA, Krishnan-Sarin S, Cavallo D, Potenza MN. Video-gaming among high school students: health correlates, gender differences, and problematic gaming. Pediatrics. 2010;126(6):e1414-24.
22. Dong G, Wang L, Du X, Potenza MN. Gaming Increases Craving to Gaming-Related Stimuli in Individuals With Internet Gaming Disorder. Biol Psychiatry Cogn Neurosci Neuroimaging. 2017;2(5):404-12.
23. Desai RA, Potenza MN. Gender differences in the associations between past-year gambling problems and psychiatric disorders. Soc Psychiatry Psychiatr Epidemiol. 2008;43(3):173-83.
24. Yip SW, Desai RA, Steinberg MA, Rugle L, Cavallo DA, Krishnan-Sarin S, Potenza MN. Health/functioning characteristics, gambling behaviors, and gambling-related motivations in adolescents stratified by gambling problem severity: findings from a high school survey. Am J Addict. 2011;20(6):495-508.
25. Dong G, Li H, Wang L, Potenza MN. Cognitive control and reward/loss processing in Internet gaming disorder: Results from a comparison with recreational Internet game-users. Eur Psychiatry. 2017;44:30-8.
26. Zhang J, Hu Y, Li H, Zheng H, Xiang M, Wang Z, Dong G. Altered brain activities associated with cue reactivity during forced break in subjects with Internet gaming disorder. Addict Behav. 2020;102:106203.
27. Noël X, Van der Linden M, d'Acremont M, Colmant M, Hanak C, Pelc I, et al. Cognitive biases toward alcohol-related words and executive deficits in polysubstance abusers with alcoholism. Addiction. 2005;100(9):1302-9.
28. Fields RD. White matter in learning, cognition and psychiatric disorders. Trends Neurosci. 2008;31(7):361-70.
29. Schouw ML, Caan MW, Geurts HM, Schmand B, Booij J, Nederveen AJ, Reneman L. Monoaminergic dysfunction in recreational users of dexamphetamine. Eur Neuropsychopharmacol. 2013;23(11):1491-502.
30. Thaler RH, Shefrin HM. An economic theory of self-control. Journal of political Economy. 1981;89(2):392-406.

31. Koob GF, Volkow ND. Neurocircuitry of addiction. Neuropsychopharmacology. 2010;35(1):217-38.
32. Metcalf O, Pammer K. Attentional bias in excessive massively multiplayer online role-playing gamers using a modified Stroop task. Computers in Human Behavior. 2011;27(5):1942-7.
33. Klaus H, Rosemann M, Gable GG. What is ERP? Information Systems Frontiers. 2000;2(2):141-62.
34. Herzog ND, Steinfath TP, Tarrasch R. Critical Dynamics in Spontaneous Resting-State Oscillations Are Associated With the Attention-Related P300 ERP in a Go/Nogo Task. Front Neurosci. 2021;15:632922.
35. Fathi M, Mazhari S, Pourrahimi AM, Poormohammad A, Sardari S. Proactive and reactive inhibitory control are differently affected by video game addiction: An event-related potential study. Brain Behav. 2022;12(6):e2584.
36. Petry NM, Rehbein F, Gentile DA, Lemmens JS, Rumpf HJ, Mößle T, et al. An international consensus for assessing internet gaming disorder using the new DSM-5 approach. Addiction. 2014;109(9):1399-406.
37. Association AP. DSM 5 Diagnostic and statistical manual of mental disorders. DSM 5 Diagnostic and statistical manual of mental disorders2013. p. 947 p.- p.
38. Young, KS (2009, Jan. 2010). Internet Addiction Test (IAT). Retrieved from http://netaddiction.com/index. php?option=combfquiz&view=onepage&catid=46&Itemid=106.
39. Idris MF, Saini SM, Sharip S, Idris NF, Ab Aziz NF. Association between the Internet Gaming Disorder and Anxiety and Depression among University Students during COVID-19 Pandemic. Healthcare (Basel). 2023;11(8).
40. van Rooij AJ, Schoenmakers TM, van den Eijnden RJ, Vermulst AA, van de Mheen D. Video game addiction test: validity and psychometric characteristics. Cyberpsychol Behav Soc Netw. 2012;15(9):507-11.
41. Kuss DJ, Pontes HM, Griffiths MD. Neurobiological Correlates in Internet Gaming Disorder: A Systematic Literature Review. Front Psychiatry. 2018;9:166.
42. Deleuze J, Nuyens F, Rochat L, Rothen S, Maurage P, Billieux J. Established risk factors for addiction fail to discriminate between healthy gamers and gamers endorsing DSM-5 Internet gaming disorder. J Behav Addict. 2017;6(4):516-24.
43. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia. 1971;9(1):97-113.
44. Beck AT, Steer RA, Brown G. Beck depression inventory–II. Psychological assessment. 1996.
45. Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. J Consult Clin Psychol. 1988;56(6):893-7.
46. Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. J Clin Psychol. 1995;51(6):768-74.
47. Cox WM, Fadardi JS, Pothos EM. The addiction-stroop test: Theoretical considerations and procedural recommendations. Psychol Bull. 2006;132(3):443-76.
48. Pourrahimi AM, Mazhari S, Shabani M, Tabrizi YM, Sheibani V. Numerical distance effect in patients with schizophrenia. Neurosci Lett. 2016;617:1-5.
49. Sardari S, Pourrahimi AM, Talebi H, Mazhari S. Symmetrical electrophysiological brain responses to unilateral and bilateral auditory stimuli suggest disrupted spatial processing in schizophrenia. Sci Rep. 2019;9(1):16454.
50. Huang G, Han C, Yang J, Ye C, Javed I, Liu F, et al. Neural basis of the attention bias during addiction stroop task in methamphetamine-dependent patients with and without a history of psychosis: an ERP study. Front Psychol. 2023;14:1173711.
51. Demirayak P, Kıyı İ, İşbitiren Y, Yener G. Cognitive load associates prolonged P300 latency during target stimulus processing in individuals with mild cognitive impairment. Sci Rep. 2023;13(1):15956.

52. Shen-Yi D, Qiang-Guo M, Xiao-Yi Y. Attentional bias to addiction-related stimuli in internet addiction patients: An ERP study. Journal of Psychological Science. 2011;34(6):1302.
53. Şalvarlı Şİ, Griffiths MD. The Association Between Internet Gaming Disorder and Impulsivity: A Systematic Review of Literature. International Journal of Mental Health and Addiction. 2022;20(1):92-118.
54. Kakul F, Javed S. Internet gaming disorder: an interplay of cognitive psychopathology. Asian Journal of Social Health and Behavior. 2023;6(1):36-45.
55. Sharifat H, Suppiah S. Electroencephalography-detected neurophysiology of internet addiction disorder and internet gaming disorder in adolescents - A review. Med J Malaysia. 2021;76(3):401-13.
56. Kim SN, Kim M, Lee TH, Lee JY, Park S, Park M, et al. Increased Attentional Bias Toward Visual Cues in Internet Gaming Disorder and Obsessive-Compulsive Disorder: An Event-Related Potential Study. Front Psychiatry. 2018;9:315.
57. Zhang C, Chen Y, Wu X, Zhao Y. Stimulating the left dorsolateral prefrontal cortex reduces attentional bias for intergroup threat. Chinese Science Bulletin. 2018;63:836-45.
58. Wills P. Attentional Bias. Decision Making in Emergency Medicine. 2021.
59. Rose AK, Brown K, Field M, Hogarth L. The contributions of value-based decision-making and attentional bias to alcohol-seeking following devaluation. Addiction. 2013;108(7):1241-9.
60. Hao Y, Li Y, Li J, Peng H, Zhao Q, Hu B. Abnormal attentional bias of non-drug reward in abstinent heroin addicts: An ERP study. IEEE Transactions on Affective Computing. 2020;13(3):1664-76.
61. Bellebaum C, Kobza S, Thiele S, Daum I. It was not MY fault: event-related brain potentials in active and observational learning from feedback. Cereb Cortex. 2010;20(12):2874-83.
62. Luo Y-J, Sun S-Y, Mai X-Q, Gu R-L, Zhang H-J. Outcome Evaluation in Decision Making: ERP Studies. In: Han S, Pöppel E, editors. Culture and Neural Frames of Cognition and Communication. Berlin, Heidelberg: Springer Berlin Heidelberg; 2011. p. 249-85.
63. Rawls E, Miskovic V, Moody SN, Lee Y, Shirtcliff EA, Lamm C. Feedback-Related Negativity and Frontal Midline Theta Reflect Dissociable Processing of Reinforcement. Front Hum Neurosci. 2019;13:452.
64. Balconi M, Venturella I, Finocchiaro R. Evidences from Rewarding System, FRN and P300 Effect in Internet-Addiction in Young People SHORT TITLE: Rewarding System and EEG in Internet-Addiction. Brain Sci. 2017;7(7).
65. Zhao Q, Li H, Hu B, Li Y, Gillebert CR, Mantini D, Liu Q. Neural Correlates of Drug-Related Attentional Bias in Heroin Dependence. Front Hum Neurosci. 2017;11:646.
66. Rostami F, Esteki A, Sarabi-Jamab A. Investigating the Interference Control in Internet Addiction Disorder: Evidence from Brain Oscillatory Activity Associated with Stroop Task. Basic and Clinical Neuroscience. 2022:0-.
67. Jones A, Petrovskaya E, Stafford T. Exploring the multiverse of analysis options for the alcohol Stroop. Behav Res Methods. 2024.