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Research on the characteristics of attentional bias in individuals with Internet Gaming Disorder

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Abstract. This study explored attentional bias towards gaming cues in individuals with Internet Gaming Disorder (IGD), a behavioral addiction sharing similarities with substance addiction. Attentional bias, comprising difficulty in disengagement, facilitated attention, and attentional avoidance, is a critical characteristic of addiction. Using both the addiction Stroop task and the Dot-Probe paradigm, the study first found no significant attentional bias difference between 28 IGD subjects and 37 Healthy Controls (HC). Subsequently, an exploratory study with 15 IGD and 17 HC subjects using adapted Dot-Probe tasks revealed that in the single-image inconsistent version, IGD subjects showed significantly longer reaction times to game pictures than to neutral pictures, indicating difficulty in disengagement. This version demonstrated higher sensitivity for measuring attentional bias than the traditional version. These findings highlight the heterogeneous nature of attentional bias in IGD.

Keywords: Internet Gaming Disorder, Dot-Probe paradigm, addiction stroop task

1. Introduction

In today's world, with the rapid development of information technology, the internet appears more frequently in people's lives, and the number of internet users continues to grow. According to data from the 57th China Statistical Report on Internet Development released in 2026, the number of internet users in China reached 1,125 million by the end of December 2025. The development of the internet has enriched our lives on one hand; instant messaging, online payments, and online shopping have brought unprecedented speed and convenience. On the other hand, the widespread use of the internet has also brought some problems. The continuous development of the internet makes its functions increasingly rich. While facilitating and entertaining people's lives, it also brings the potential for addiction. By the end of December 2025, the average weekly online time for internet users in China reached 32.5 hours. The problems caused by unreasonable internet use in people's lives and work are becoming increasingly prominent. At the same time, the issue of internet addiction caused by unreasonable internet use is attracting more and more attention.

1.1. Attentional bias

Attentional bias refers to an individual's high sensitivity to a specific stimulus and individual differences in the allocation of attention to the stimulus that triggers the bias [1]. Essentially, attentional bias involves the orientation and maintenance of psychological processing resources toward specific information and the exclusion of processing other irrelevant stimuli. From a cognitive perspective, attentional bias is the investment of psychological resources in processing specific information and the exclusion of processing other information [2]. Generally, there are currently two explanations for attentional bias: one suggests that, compared to neutral stimuli, attentional bias involves individuals allocating more attentional resources to threatening or relevant stimuli [3]. The other view holds that an individual's selective attention to information constitutes attentional bias [4].

By summarizing research in the field of attentional bias in anxiety disorder populations, Cisler and Koster proposed that attentional bias has three components: (1) Difficulty in Disengagement. Difficulty in disengagement refers to the inability of an individual's attentional resources to disengage quickly from stimuli that trigger attentional bias, making it difficult to attend to other stimuli. Past research using spatial cueing tasks and visual search tasks has identified difficulty in disengagement [5, 6]. (2) Facilitated Attention. Facilitated attention refers to individuals noticing certain specific stimuli more quickly, they exhibit a bias when attending to these stimuli. (3) Attentional Avoidance. Attentional avoidance refers to individuals being more inclined to shift their attentional resources to opposite or contrasting stimuli when specific stimuli appear [7].

In research on attentional bias using the Dot-probe paradigm, the presentation duration of cue pictures is often related to different components of attentional bias. Shorter presentation durations (typically less than 200ms) reflect facilitated attention, while longer presentation durations (typically greater than 450ms) are associated with difficulty in disengagement [8, 9].

1.2. Common research paradigms for attentional bias

In behavioral research on attentional bias, several paradigms are commonly used: the Stroop paradigm, visual probe paradigm, cue-target paradigm, attentional blink paradigm, "dual-task" procedure, visual search paradigm, and priming paradigm. Among these, the Stroop paradigm and the visual probe paradigm are most widely used in attentional bias research, especially in the field of addiction.

1.2.1. Stroop paradigm

The Stroop paradigm is a classic psychological paradigm proposed by Stroop in 1935. The Stroop effect refers to the phenomenon where, when naming the color of ink used to write meaningful versus meaningless stimulus words, the naming speed for meaningful words is significantly slower than for meaningless words. This indicates that, during naming, the semantic information and color information from the same stimulus interfere with each other. In the Stroop effect, when faced with the word "red" written in green ink, "red" as the word's meaning is the dominant response that needs to be inhibited, and the participant needs to respond to the color "green". This effect occurs because naming the word's meaning triggers response competition, thus slowing down the response to the target of measurement. Compared to other tasks, the Stroop task requires responses to both congruent and incongruent stimuli. Participants performing the Stroop task require more attention and action capacity, and its processing is more complex. Therefore, the Stroop paradigm is also considered a classic paradigm for testing cognitive conflict and attentional bias. Adapted versions of the Stroop were first used in research on emotional attentional bias, where researchers used emotional words and neutral words as stimuli, termed the emotional Stroop [10]. Subsequently, adapted Stroop versions have been applied in various fields of mental illness research.

In measuring attentional bias within the addiction field, adapted versions of the addiction Stroop paradigm are often used based on the type of addictive substance. In an addiction Stroop task conducted with individuals with IGD used an adapted addiction Stroop with office-related words as neutral stimuli and computer-related words as addiction stimuli [9]. They found that game-addicted participants exhibited longer reaction times to addiction-related stimuli compared to neutral stimuli, indicating an attentional bias towards addiction cues.

1.2.2. Dot-probe paradigm

The Dot-probe paradigm was proposed by MacLeod and is also known as the visual probe paradigm [11]. The Dot-probe paradigm primarily investigates attentional bias within the same spatial plane. The theoretical assumption of the traditional Dot-probe paradigm is that an individual's attention exists within a specific attentional region. The closer the probe is to the attentional region, the faster the participant's response speed and the shorter the reaction time; conversely, the reaction time is longer.

In research using the visual probe paradigm to study attentional bias in individuals with IGD, findings have been inconsistent. In a study by Lorenz, using game pictures as addiction stimuli and inanimate objects as neutral stimuli, they found that game addicts exhibited an attentional bias towards gaming cues compared to healthy controls [12]. However, in a study by Van Holst using the Dot-probe paradigm with male adolescents with IGD, using game pictures as addiction stimuli and non-game animation pictures as neutral stimuli, they found no correlation between addiction scores and task reaction times in the IGD group. However, the study did find that when the probe appeared in the neutral picture location, addicts made more errors. This might be because addicts paid more attention to the game pictures, meaning the game pictures occupied more attentional and cognitive resources of the addicted individuals [13]. Although this study did not find significant differences in reaction times between neutral and addiction stimuli in IGD participants, the results can still be interpreted as indicating that IGD individuals allocate more attention to gaming addiction stimuli.

Both the Stroop task and the Dot-probe paradigm are classic tasks commonly used to measure attentional bias in addicts and are widely applied in attentional bias research within the addiction field. Both have their respective emphases in measuring attentional bias. Although the Stroop task cannot easily distinguish between the facilitated attention and difficulty in disengagement components, it can measure attentional bias in addicts from a temporal perspective. The Dot-probe paradigm can differentiate components of attentional bias based on different picture presentation durations: shorter durations (less than 200 ms) represent facilitated attention, while longer durations (greater than 200 ms) represent difficulty in disengagement. The Dot-probe paradigm can better measure attentional bias in addicts from a spatial perspective [14, 15]. Both tasks are common experimental paradigms for measuring attentional bias in addicts.

2. Method

2.1. Hypotheses

This study will investigate the attentional bias of individuals with IGD. It will measure attentional bias in IGD individuals using adapted versions of the addiction Stroop task and the Dot-probe paradigm to reveal the characteristics of their attentional bias. The hypotheses of this study are as follows:

Compared to healthy control participants, individuals with IGD exhibit an attentional bias towards gaming cues. This bias can be manifested in behavioral tasks, such as reaction times in the addiction Stroop and Dot-probe paradigms. In the addiction Stroop task, attentional bias is shown by the IGD group having longer reaction times to game-related words compared to neutral words, relative to the HC group. In the Dot-probe paradigm, attentional bias is shown by the IGD group having faster reaction times when the probe is in a location consistent with a game picture compared to when it is consistent with a neutral picture, relative to the HC group.

2.2. Study design

The purpose of Study was to measure whether individuals with IGD exhibit an attentional bias towards addiction cues by comparing them with healthy control participants. This study used adapted versions of the IGD addiction Stroop task and the Dot-Probe Paradigm to measure attentional bias in individuals with IGD. The hypothesis was that, in both the addiction Stroop task and the Dot-Probe Paradigm, IGD participants would show an attentional bias towards gaming cues compared to HC participants. In the addiction Stroop task, attentional bias would manifest as significantly slower reaction times to addiction cues compared to neutral cues in the IGD group relative to the HC group. In the Dot-Probe Paradigm, attentional bias would manifest as faster reaction times when the probe was in a location consistent with a game picture compared to when it was consistent with a neutral picture in the IGD group relative to the HC group.

2.3. Participants

The participants in this study included IGD subjects and HC subjects. A total of 37 HC subjects and 28 IGD subjects were recruited.

The inclusion criteria for IGD subjects were: (1) DSM-5 score of 5 or above, and Young's IAT scale score of 50 or above; (2) Playing games for 20 hours or more per week, with this state lasting for more than 12 months; (3) Age between 18 and 30 years old; (4) Exclusion of participants diagnosed with mental disorders (such as depression, attention deficit hyperactivity disorder, obsessive-compulsive disorder) or physical diseases, as well as substance addictions (tobacco, alcohol, cocaine, etc.) assessed using structured interviews and the Mini-International Neuropsychiatric Interview (M.I.N.I).

For healthy control participants, the inclusion criteria were: (1) DSM-5 score below 5, and Young's IAT scale score below 50; (2) Playing games infrequently (< 10 hours per week) or not at all; (3) Age between 18 and 30 years old; (4) Exclusion of participants diagnosed with mental disorders or physical diseases, as well as substance addictions, assessed using structured interviews and the M.I.N.I.

2.4. Experimental materials and procedure

2.4.1. Experimental tools

(1) Self-developed recruitment screening questionnaire.Included basic demographic variables, information on internet gaming behavior over the last twelve months, etc.

(2) Internet Gaming Disorder Questionnaires. Included the DSM-5 scale and Young's IAT scale.

(3) Other personality trait-related scales.

Behavioral Inhibition/Activation System Scale (BIS-BAS). The scale includes two subscales, totaling 13 items. It uses a 4-point scale from "1" (Strongly disagree) to "4" (Strongly agree). Gray proposed a neuropsychological theory of personality, explaining how certain brain-related personality traits predispose individuals to psychological disorders [16]. Scores for each dimension are averaged; higher scores indicate a higher tendency or level of that trait. In this study, Cronbach's alpha coefficients for the inhibition subscale, approach subscale, and the total scale were α = 0.745, α = 0.817, and α = 0.807, respectively.

Brief Self-Control Scale (BSC). The Brief Self-Control Scale (BSC) was used to measure participants' self-control levels. The scale comprises 7 items, including two sub-dimensions: self-discipline and impulse control. It uses a five-point scale (1 = "Strongly disagree" to 5 = "Strongly agree"). Higher scores on the "self-discipline" dimension indicate higher levels of self-discipline. Higher scores on the "impulse control" dimension indicate poorer impulse control ability. In this study, Cronbach's alpha coefficients for the self-discipline and impulse control sub-dimensions were α = 0.720 and α = 0.720, respectively.

Assessment of Depression and Anxiety. The Beck Depression Inventory was used to assess participants' depressive problems and severity over the past two weeks. The scale has 21 items, rated on a 0-3 scale. The Beck Anxiety Inventory was used to assess participants' clinical anxiety levels. The scale has 21 items, rated on a 0-3 scale. In this study, Cronbach's alpha coefficients for the two scales were α = 0.970 and α = 0.963, respectively.

Internet Self-Control Efficacy Scale. Internet self-control efficacy was measured using the "Internet Self-Control Self-Efficacy Scale". This scale consists of 12 items using a four-point scale, covering aspects like time control, task control, and purpose clarity. It comprises only one dimension, with higher scores indicating higher internet control self-efficacy. In this study, Cronbach's alpha for this scale was α = 0.927.

Positive and Negative Affect Schedule (PANAS). The PANAS scale includes 10 positive affect descriptors and 10 negative affect descriptors. Participants rated on a 5-point scale (1 = "Very slightly or not at all" to 5 = "Extremely") the extent to which they experienced the emotions described by these words over the past week. Scores for each dimension are averaged; higher scores indicate a higher tendency or level of that trait. In this study, Cronbach's alpha coefficients for the positive affect dimension, negative affect dimension, and the total scale were α = 0.871, α = 0.812, and α = 0.823, respectively.

Metacognitions Questionnaire (MCQ30). This includes 30 items, rated on a 4-point Likert scale: 1 = "Do not agree at all" to 4 = "Agree very much". The questionnaire assesses five domains of metacognition relevant to psychopathology: (1) Cognitive Confidence (CC), evaluation of one's own cognitive abilities like memory and attention; (2) Positive Beliefs about Worry (POS), believing that worrying can lead to positive outcomes or avoid danger; (3) Cognitive Self-Consciousness (CSC), the tendency to focus attention on one's own thought processes; (4) Negative Beliefs about Uncontrollability and Danger of Worry (NEG), negative beliefs about worry, considering it uncontrollable and dangerous; (5) Need to Control Thoughts (NC), the belief that one should control one's thoughts. In this study, Cronbach's alpha coefficients for the five sub-dimensions and the total scale were α = 0.817, α = 0.895, α = 0.859, α = 0.822, α = 0.677, and α = 0.848, respectively.

2.4.2. Experimental tasks

2.4.2.1. Addiction stroop task

The addiction Stroop task was programmed using E-prime 2.0. The task consisted of 160 trials. Experimental materials comprised 20 game-related words randomly matched from games like "Honor of Kings," "League of Legends," and "Peacekeeper Elite," and 20 neutral words related to household items. Participants were required to respond by pressing a key corresponding to the color of the font (red, yellow, blue, green). Each participant chose a version based on the game(s) they frequently played. Each trial presented a stimulus for 3,000 ms. Game-related and neutral words were presented randomly. Participants were instructed to press the key for the font color as quickly and accurately as possible. They had to respond within 3,000 ms of stimulus onset; the stimulus disappeared immediately upon response. A 1,000 ms "+" fixation was presented between stimuli for transition (see Figure 1).

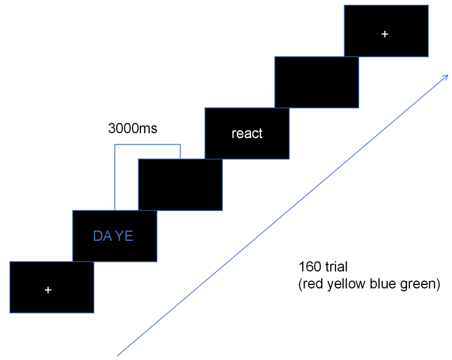

Figure 1. Addiction stroop task schematic

2.4.2.2. Dot-Probe Paradigm

The Dot-Probe Paradigm was programmed using Matlab with the Psychtoolbox for presentation. Participants viewed 16 neutral pictures and 16 game-related pictures. Subsequently, two types of probes appeared randomly, and participants needed to press a key corresponding to the probe type upon its appearance. In the Dot-Probe Paradigm, a fixation point was presented first, followed by a pair of neutral and game pictures presented simultaneously for 600 ms. After the pictures disappeared, a probe appeared for 300 ms either in the location of the game picture or the neutral picture. Participants had 1,500ms to press a key indicating the probe type (see Figure 2).

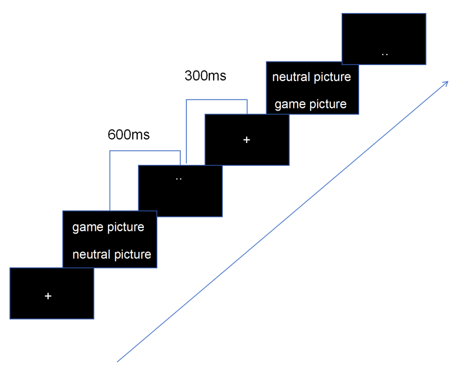

Figure 2. Traditional Dot-probe paradigm schematic

2.4.2.3. Newly developed Dot-Probe Paradigm versions

In the traditional Dot-Probe Paradigm, a neutral picture and a game picture are presented as a pair. The probe appears either in the location consistent with the game picture (inconsistent with the neutral picture) or consistent with the neutral picture (inconsistent with the game picture). Participants need to press a key based on the probe type. Therefore, we split the Dot-Probe Paradigm into three different versions to explore factors that might yield more sensitive measurements of attentional bias. In Version 1, controlling for the picture type at the inconsistent probe location, neutral-neutral and game-game picture pairs were presented. In Version 2, to measure the impact of the picture type at the probe location on attentional bias, single pictures (neutral or game) were presented, with the probe appearing in a location consistent with the picture. In Version 3, to measure the impact of the picture type not at the probe location on attentional bias, single pictures (neutral or game) were presented, with the probe appearing in a location inconsistent with the picture.

Visual Probe Version 1 (Same-type Stimulus Pair)

Visual Probe Version 1 was programmed using Matlab with Psychtoolbox. Version 1 presented neutral-neutral and game-game picture pairs. Participants needed to press a key for the probe type after the pictures disappeared. There were 64 trials, with the picture type and probe location counterbalanced within the design (see Figure 3).

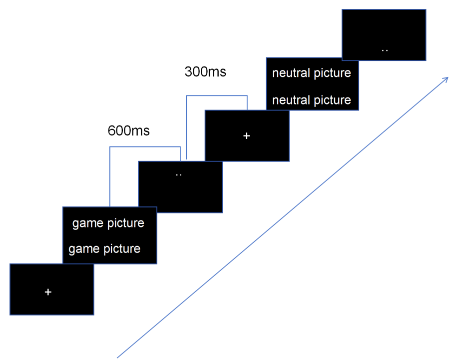

Figure 3. Exploratory Dot-probe paradigm version 1 schematic

Visual Probe Version 2 (Single-image Consistent Version)

Visual Probe Version 2 was programmed using Matlab with Psychtoolbox. Version 2 presented a single picture (neutral or game), with the probe appearing in a location consistent with the picture. Participants needed to press a key for the probe type after the picture disappeared. There were 64 trials, with the picture location and probe location counterbalanced within the design (see Figure 4).

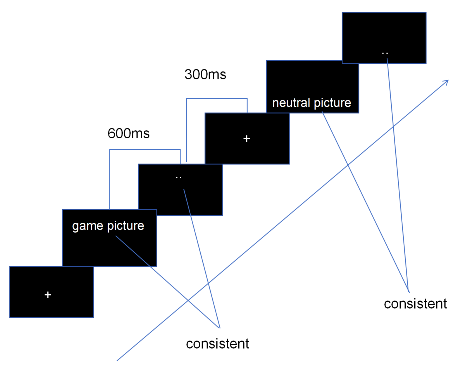

Figure 4. Exploratory Dot-probe paradigm version 2 schematic

Visual Probe Version 3 (Single-image Inconsistent Version)

Visual Probe Version 3 was programmed using Matlab with Psychtoolbox. Version 3 presented a single picture (neutral or game), with the probe appearing in a location inconsistent with the picture. Participants needed to press a key for the probe type after the picture disappeared. There were 64 trials, with the picture location and probe location counterbalanced within the design (see Figure 5).

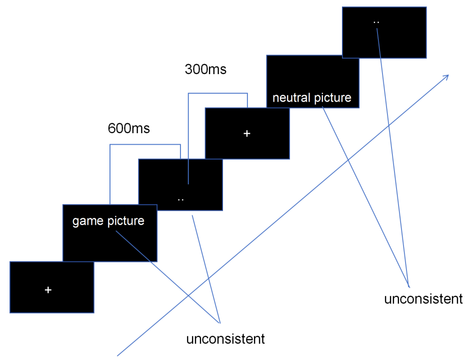

Figure 5. Exploratory Dot-probe paradigm version 3 schematic

The three versions of the Dot-Probe Paradigm were used only in the subsequent exploratory study.

2.5. Experimental procedure

Preliminary Preparation: Before the experiment began, a total of 30 commonly used game-related words from "Honor of Kings," "Peacekeeper Elite," and "League of Legends" were collected as game stimulus words, and 30 commonly used household item words were collected as neutral words through prior collection and interviews. Five or more players of each game were invited to rate and screen the game and neutral words using a 1-9 scale (1 = very irrelevant, 9 = very relevant). Based on their ratings, 20 game-related words and 20 neutral words were selected for experimental use. Participants involved in this rating process did not participate in the subsequent experiment.

Formal Experiment: Participant recruitment information was released via the internet. Participants who passed all questionnaire screenings came to the laboratory to complete the addiction Stroop task and the Dot-Probe Paradigm. After the experiment, participants were compensated.

3. Results

The attentional bias measurement tasks consisted of the IGD addiction Stroop task and the Dot-Probe Paradigm. Data from scales like the DSM-5 were collected using Questionnaire Star. Raw data were imported into SPSS 22.0 for management and analysis. Based on previous research, in the addiction Stroop task, trials with incorrect responses, reaction times less than 200 ms or greater than 2,000 ms, and those exceeding three standard deviations from the mean were excluded. In the addiction Stroop task, the attentional bias score for IGD was defined as the difference between reaction time to game word colors and reaction time to neutral word colors. In the Dot-Probe Paradigm, the attentional bias score was defined as the difference between reaction time when the probe was consistent with the game picture and reaction time when the probe was consistent with the neutral picture.

To explore differences in attentional bias towards gaming cues between IGD participants and healthy control participants, an independent samples t-test was conducted on attentional bias scores from the addiction Stroop task for the IGD and HC groups. For the Dot-Probe Paradigm, a 2 (Probe Location Picture Type: game picture, neutral picture) × 2 (Group: IGD group, HC group) repeated measures ANOVA was used, with group as the between-subjects factor and probe location picture type as the within-subjects factor.

Independent samples t-tests were used to test for differences in scores on the DSM-5, IAT, and other scales between the IGD and HC groups.

3.1. Demographic variables

A total of 65 participants were recruited for the study, including 28 individuals with IGD and 37 healthy controls. Independent samples t-tests (for continuous variables) or chi-square tests (for categorical variables) were conducted on demographic variables between the IGD and HC groups. As shown in table 1, the IGD and HC groups did not differ significantly in age, years of education, or gender distribution, indicating no differences in basic personal information. As expected from the inclusion criteria, the two groups differed significantly in weekly gaming time, duration of gaming (months), DSM-5 scores, IAT scores, metacognition scores, internet self-efficacy scores, depression levels, and anxiety levels.

Table 1. Demographic characteristics of participants

Variable	IGD (N = 28) M ± SD	HC (N = 37) M ± SD	t / x^2	p
Age	22.14 ± 2.56	21.50 ± 2.69	1.034	0.305
Years of education	16.61 ± 2.15	15.73 ± 2.19	0.202	0.112
Gender(male/female)	19/9	16/21	-1.956	0.0504
Weekly gaming time	25.07 ± 6.35	4.51 ± 5.96	13.388***	< 0.001
Gaming duaration(month)	16.93 ± 11.55	7.73 ± 12.67	3.01**	0.004
DSM-5	6.46 ± 1.20	1.65 ± 1.49	13.965***	< 0.001
IAT	63.75 ± 12.02	32.92 ± 13.77	9.432***	< 0.001
Self-control	10.41 ± 1.29	10.11 ± 1.86	0.735	0.465
BIS/BAS	9.90 ± 1.34	9.76 ± 1.24	0.430	0.669
Panas_negative affect	19.82 ± 5.84	18.05 ± 5.44	1.257	0.214
PANAS_positive affect	29.21 ± 6.59	31.97 ± 5.49	-1.840	0.071
MCQ-30	14.71 ± 1.67	13.69 ± 2.27	2.02*	0.048
Internet control self-efficacy	25.89 ± 6.61	33.35 ± 6.52	-4.54***	< 0.001
Beck anxiety	6.29 ± 6.27	3.54 ± 4.75	2.010*	0.049
Beck depression	8.46 ± 6.09	3.54 ± 4.26	3.653**	0.001
Alcohol use [a]	3.17 ± 2.93	2.50 ± 1.38	0.505	0.625
Nicotine dependence [b]	2.33 ± 2.08	3.60 ± 3.78	-0.523	0.619

Note: * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$. M = mean, SD = standard deviation. IAT: YOUNG Internet Gaming Addiction Scale score. (Same below)

a: Total drinking participants = 12 (IGD 6, HC 6). b: Total smoking participants = 7 (IGD 2, HC 5).

3.2. Characteristics of attentional bias between groups: performance on the addiction stroop task

As shown in Table 2, the IGD group had a higher mean attentional bias score than the HC group. However, an independent samples t-test on the attentional bias scores showed that this difference was not statistically significant, $t_{(1,63)}$= 0.247, p = 0.806, d = 0.012. For game-related words, the mean reaction time of the IGD group (766.24 ms) was longer than that of the HC group (720.97 ms), but this difference was not significant,

$t_{(1,63)}$ = 1.181, p = 0.242, d = 0.052. For neutral words, the mean reaction time of the IGD group (756.34 ms) was also longer than that of the HC group (714.41 ms), and this difference was not significant, $t_{(1,63)}$ = 1.122, p = 0.266, d = 0.050.

Table 2. Statistical analysis results for the stroop task in both groups

	IGD (N = 28)	HC (N = 37)	t	p	Cohen d
	M ± SD	M ± SD			
Game word RT (ms)	766.24 ± 154.60	720.97 ± 151.80	1.181	0.242	0.052
Neutral word RT (ms)	756.34 ± 152.96	714.41 ± 146.24	1.122	0.266	0.050
Attentional bias score	9.89 ± 62.99	6.56 ± 38.67	0.247	0.806	0.012

Note: RT: reaction time, Attentional Bias Score: Game-Neutral. (same below)

3.3. Characteristics of attentional bias between groups: performance on the Dot-probe paradigm

In Table 3, a 2 (Probe Location Picture Type: game picture, neutral picture) × 2 (Group: IGD, HC) repeated measures ANOVA on reaction times in the Dot-Probe Paradigm showed a significant main effect of picture type, $F_{(1,63)}$ = 9.825, p = 0.003, η^2 = 0.135. However, the main effect of group was not significant, $F_{(1,63)}$ = 0.025, p = 0.876, η^2 < 0.001. The interaction involving group (group × picture type) was also not significant, $F_{(1,63)}$ = 0.270, p = 0.605, η^2 = 0.004. An independent samples t-test on attentional bias scores for the two groups showed no significant difference, $t_{(1,63)}$ = 0.520, p = 0.605, d = 0.022.

Table 3. Statistical analysis results for the Dot-probe paradigm in both groups

	IGD (N = 28)	HC (N = 37)	t / F	p	Cohen d / η^2
	M ± SD	M ± SD			
Game picture RT (ms)	763.19 ± 142.38	755.55 ± 117.10	F_{Group} = 0.025	0.876	< 0.001
Neutral picture RT (ms)	744.33 ± 126.52	742.06 ± 127.44	$F_{Picture\ Type}$ = 9.825**	0.003	0.135
			$F_{Group\times Picture\ Type}$ = 0.270	0.605	0.004
Attentional bias score	1.89 ± 3.65	1.35 ± 4.44	t = 0.520	0.605	0.022

3.4. Exploratory Dot-probe paradigm: rationale and results

3.4.1. Rationale

To investigate the influence of picture type and probe location on reaction times in the two groups, the traditional Dot-Probe Paradigm was deconstructed into three exploratory versions. In the traditional version, neutral and game pictures appear as a pair, and the probe appears randomly in the location of either the neutral or game picture. Participants judge the probe's shape. A single trial measures the effects of two different picture types and the probe's location (neutral/game picture) on attentional bias. Since the traditional version did not reveal attentional bias in IGD participants relative to HC participants, based on Donders' subtractive method, the factors measured in the task were broken down to explore a more sensitive measurement paradigm for attentional bias in IGD. This study adapted the traditional Dot-Probe Paradigm into three new versions: Version 1 (same-type stimulus pair): controlling for picture type at the inconsistent probe location, presenting neutral-neutral and game-game pairs; Version 2 (single-image consistent): measuring the effect of picture type at the probe location, presenting single pictures (neutral/game) with the probe consistent with the picture location; Version 3 (single-image inconsistent): measuring the effect of picture type not at the probe location, presenting single pictures (neutral/game) with the probe inconsistent with the picture location. Detailed task descriptions are in the Experimental Tasks section above.

3.4.2. Demographic variables

Fifteen IGD subjects and 17 HC subjects were recruited. In addition to completing the traditional Dot-Probe Paradigm from the initial study, participants completed the three different versions of the Dot-Probe Paradigm for the exploratory study. As shown in Table 4, independent samples t-tests or chi-square tests on demographic variables between the IGD and HC groups showed no significant differences in age, years of education, or gender distribution, indicating no differences in basic personal information. As expected from the inclusion criteria, the two groups differed significantly in weekly gaming time, duration of gaming (months), DSM-5 scores, IAT scores, internet self-efficacy scores, and depression levels.

Table 4. Demographic characteristics of participants in exploratory Dot-probe paradigm

Variables	IGD (N = 15) M ± SD	HC (N = 17) M ± SD	t / x^2	p
Age	22.67 ± 2.23	20.41 ± 5.76	1.424	0.165
Years of education	16.47 ± 1.36	15.76 ± 1.92	1.179	0.248
Gender (male/female)	11/4	7/10	-1.801	0.072
Weekly gaming time	28.07 ± 7.20	1.09 ± 1.15	14.360***	< 0.001
Gaming duaration (month)	21.33 ± 13.41	5.53 ± 7.05	4.091**	0.001
DSM-5	6.33 ± 1.18	0.82 ± 1.33	12.321***	< 0.001
IAT	63.00 ± 12.59	23.82 ± 5.03	11.282***	< 0.001
Self-control	10.47 ± 1.45	9.88 ± 1.63	1.065	0.295
BIS/BAS	9.72 ± 1.22	9.75 ± 1.52	-0.068	0.946
Panas_negative affect	19.76 ± 6.67	19.24 ± 6.32	0.217	0.830
PANAS_positive affect	29.07 ± 6.70	32.47 ± 3.69	-1.808	0.081
MCQ-30	15.01 ± 1.63	14.32 ± 2.61	0.891	0.380
Internet control self-efficacy	24.33 ± 6.68	33.00 ± 6.92	-3.592**	0.001
Beck anxiety	6.47 ± 4.84	4.76 ± 6.16	0.861	0.396
Beck depression	9.27 ± 6.41	4.59 ± 5.37	2.246*	0.032
Alcohol use [a]	3.50 ± 3.70	2.40 ± 1.52	0.559	0.608
Nicotine dependence [b]	1.50 ± 2.12	—	—	—

Note: a: Total drinking participants = 8 (IGD 3, HC 5). b: Total smoking participants = 2 (IGD 2).

3.4.3. Traditional Dot-probe paradigm

In Table 5, a 2 (Probe Location: game picture consistent, neutral picture consistent) × 2 (Group: IGD, HC) repeated measures ANOVA on reaction times showed that the main effect of picture type was not significant, $F_{(1,30)} = 2.531$, $p = 0.122$, $\eta^2 = 0.078$. The main effect of group was not significant, $F_{(1,30)} = 0.001$, $p = 0.979$, $\eta^2 < 0.001$. The interaction (group × picture type) was also not significant, $F_{(1,30)} = 0.557$, $p = 0.461$, $\eta^2 = 0.018$. An independent samples t-test on attentional bias scores showed no significant difference between groups, $t_{(1,30)}$ = 0.746, p = 0.461, d = -0.136. The results for the traditional Dot-Probe Paradigm in the newly recruited sample were consistent with the initial study.

Table 5. Statistical analysis results for traditional Dot-probe paradigm in both groups

	IGD (N = 15)	HC (N = 17)	t / F	p	Cohen d / η^2
	M ± SD	M ± SD			
Game picture RT (ms)	748.35 ± 143.09	758.17 ± 143.32	F_{Group} = 0.001	0.979	< 0.001
Neutral picture RT (ms)	741.92 ± 148.33	745.46 ± 138.01	$F_{Picture\ Type}$ = 2.531 $F_{Group \times Picture\ Type}$ = 0.557	0.122 0.461	0.078 0.018
Attentional bias score	1.53 ± 3.16	0.55 ± 4.09	t = 0.746	0.461	-0.136

3.4.4. Exploratory Dot-probe paradigm 1 (same-type stimulus pair)

Exploratory Dot-Probe Paradigm Version 1 presented neutral-neutral and game-game picture pairs simultaneously. Data were processed to calculate mean reaction times for each group under game picture and neutral picture conditions. In Table 6, a 2 (Picture Type: neutral picture, game picture) × 2 (Group: IGD, HC) repeated measures ANOVA showed that the main effect of picture type was not significant, $F_{(1,30)}$ = 2.422, p = 0.130, η^2 = 0.075. The main effect of group was not significant, $F_{(1,30)}$ = 0.008, p = 0.930, η^2 < 0.001. The interaction (group × picture type) was also not significant, $F_{(1,30)}$ = 0.050, p = 0.824, η^2 = 0.002. An independent samples t-test on attentional bias scores showed no significant difference between groups, $t_{(1,30)}$ = -0.224, p = 0.824, d = -0.40.

Table 6. Statistical analysis results for paradigm 1 in both groups

	IGD (N = 15)	HC (N = 17)	t / F	p	Cohen d / η^2
	M ± SD	M ± SD			
Game picture RT (ms)	725.17 ± 152.87	731.31 ± 141.67	F_{Group} = 0.008	0.930	< 0.001
Neutral picture RT (ms)	716.77 ± 150.73	720.08 ± 158.03	$F_{Picture\ Type}$= 2.422 $F_{Group \times Picture\ Type}$ = 0.050	0.130 0.824	0.075 0.002
Attentional bias score	0.84 ± 4.28	1. 12 ± 2.79	t = -0.224	0.824	-0.40

3.4.5. Exploratory Dot-probe paradigm 2 (single-image consistent version)

Dot-Probe Paradigm 2 presented single pictures (game, neutral) with the probe appearing in a location consistent with the picture. Reaction times were calculated for each condition.As shown in Table 7, a 2 (Picture Type: neutral picture, game picture) × 2 (Group: IGD, HC) repeated measures ANOVA showed that the main effect of picture type was not significant, $F_{(1,30)}$ = 0.006, p = 0.939, η^2 < 0.001. The main effect of group was not significant, $F_{(1,30)}$ = 0.500, p = 0.485, η^2 = 0.016. The interaction (group × picture type) was also not significant, $F_{(1,30)}$ = 0.174, p = 0.680, η^2 = 0.006 An independent samples t-test on attentional bias scores showed no significant difference between groups, $t_{(1,30)}$ = 0.417, p = 0.680, d = -0.363.

Table 7. Statistical analysis results for paradigm 2 in both groups

	IGD (N = 15)	HC (N = 17)	t / F	p	Cohen d / η^2
	M ± SD	M ± SD			
Game picture RT (ms)	689.01 ± 140.40	722.94 ± 159.07	F_{Group} = 0.500	0.485	0.016
Neutral picture RT (ms)	685.49 ± 152.73	728.05 ± 166.39	$F_{Picture\ Type}$ = 0.006	0.939	< 0.001
			$F_{Group \times Picture\ Type}$ = 0.174	0.680	0.006
Attentional bias score	0.35 ± 6.21	-0.51 ± 5.51	t = 0.417	0.680	-0.363

3.4.6. Exploratory Dot-probe paradigm 3 (single-image inconsistent version)

Dot-Probe Paradigm 3 presented single pictures (neutral, game) with the probe appearing in a location inconsistent with the picture. As shown in Table 8, reaction times were calculated for each picture type. A 2 (Picture Type: neutral picture, game picture) × 2 (Group: IGD, HC) repeated measures ANOVA showed that the main effect of picture type was not significant, $F_{(1,30)}$ = 0.029, p = 0.867, η^2= 0.001. The main effect of group was not significant, $F_{(1,30)}$ = 0.358, p = 0.554, η^2= 0.012. The interaction (group × picture type) was significant, $F_{(1,30)}$ = 4.244, p = 0.048, η^2= 0.124. An independent samples t-test on attentional bias scores showed a significant difference between groups, $t_{(1,30)}$ = 2.121, p = 0.043, d = -0.094.

Table 8. Statistical analysis results for paradigm 3 in both groups

	IGD (N = 15)	HC (N = 17)	t / F	p	Cohen d / η^2
	M ± SD	M ± SD			
Game picture RT(ms)	686.06 ± 141.78	701.78 ± 159.69	F_{Group} = 0.358	0.554	0.012
Neutral picture RT(ms)	669.35 ± 141.71	715.95 ± 148.16	$F_{Picture\ Type}$ = 0.029	0.867	0.001
			$F_{Group \times Picture\ Type}$ = 4.244*	0.048	0.124
Attentional bias score	1.67 ± 3.09	-1.42 ± 5.02	t = 2.121*	0.043	-0.094

In Table 9, a 2 (Version: traditional version, version 3) × 2 (Probe Location Picture Type: game picture, neutral picture) × 2 (Group: IGD, HC) repeated measures ANOVA was conducted. Results showed that the main effect of task version was not significant, $F_{(1,30)}$ = 1.673, p = 0.206, η^2 = 0.053. The main effect of probe location picture type was significant, $F_{(1,30)}$ = 26.278, p < 0.001, η^2 = 0.467. The main effect of group was not significant, $F_{(1,30)}$ = 0.104, p = 0.749, η^2 = 0.003. The interaction between group and version was significant, $F_{(1,30)}$ = 5.083, p = 0.032, η^2 = 0.145. Other interactions involving group were not significant (three-way interaction: $F_{(1,30)}$ = 0.960, p = 0.335, η^2 = 0.031; group × picture type interaction: $F_{(1,30)}$ = 1.945, p = 0.173, η^2 = 0.061). The version × picture type interaction was not significant, $F_{(1,30)}$ = 0.714, p = 0.405, η^2 = 0.023.

Table 9. Comparative statistical analysis results for paradigm 3 and traditional paradigm

Variables		F	p	η^2
Reaction time	Group	0.104	0.749	0.003
	Picture Type	26.278***	< 0.001	0.467
	Version	1.673	0.206	0.053
	Group × Picture Type	1.945	0.173	0.061
	Group × Version	5.083*	0.032	0.145
	Version × Picture Type	0.714	0.405	0.023
	Group × Version × Picture Type	0.960	0.335	0.031

4. Discussion

In this study, attentional bias towards addiction cues was measured in 28 IGD participants and 37 HC participants using behavioral experiments combining the addiction Stroop task and the visual probe paradigm. In the addiction Stroop task, an independent samples t-test on attentional bias scores revealed no statistically significant difference between IGD and HC participants. While IGD participants showed longer reaction times to game words than HC participants, this difference was not significant. In the Dot-Probe Paradigm, only a significant main effect of picture type was found, with no significant differences in task performance between the two groups across experimental conditions.

In both the IGD addiction Stroop task and the Dot-Probe Paradigm, this study used both word and picture stimulus types. For HC participants, the addiction-related words in the Stroop task and the game pictures in the Dot-Probe Paradigm are novel stimulus types. This novelty might cause HC participants to have longer reaction times to game-related cues compared to neutral cues. This could potentially explain the lack of significant difference in attentional bias scores between the two groups.

The results of the addiction Stroop task did not support the initial hypothesis: there was no significant difference in attentional bias scores between IGD and HC participants. This finding is consistent with the results of Holst [13]. It might be related to the fact that online gaming can enhance users' reaction speed and selective attention abilities, potentially affecting the measurement of reaction times [13, 17, 18]. However, our study did not find faster reaction times in addicts, which could be due to inconsistencies between the task's key-press rules and gaming key-press rules [9].

The traditional Dot-Probe Paradigm also failed to reveal attentional bias in IGD participants; there was no difference in reaction times when the probe was consistent with game pictures versus neutral pictures. This might be related to game pictures occupying more attentional processing and cognitive resources [13].

Compared to HC participants, IGD participants did not show significant attentional bias in the addiction Stroop and Dot-Probe Paradigms. Although previous studies on IGD using these tasks have yielded inconsistent results, this study aimed to explore the factors contributing to this non-significant finding and to search for more sensitive measurement paradigms for attentional bias. Since the Stroop paradigm has fewer variants and is less modifiable, this exploratory study focused on variations of the Dot-Probe Paradigm.

Based on previous research and Donders' subtractive method, the traditional Dot-Probe Paradigm was deconstructed into three simpler versions for the exploratory study. Besides the traditional task, three different Dot-Probe Paradigm paradigms were used: 1. Same-type stimulus pair version; 2. Single-image consistent version; 3. Single-image inconsistent version.

The exploratory study recruited an additional 15 IGD participants and 17 HC participants. They completed the traditional Dot-Probe Paradigm (neutral-game pairs) and the three new versions. When analyzing the different versions separately using repeated measures ANOVA, a significant picture type × group interaction was found specifically in the version where the probe appeared in a location inconsistent with the single picture (neutral or game). This partially supports the hypothesis related to the study. To validate the effectiveness of this task version, it was compared with the traditional version using repeated measures ANOVA. A significant group × version interaction emerged, indicating that presenting a single picture with the probe in an inconsistent location may more readily trigger difficulty in disengaging attention from gaming cues in individuals with IGD. This paradigm might be a more sensitive measurement tool for assessing attentional bias in IGD.

This study conducted a series of investigations on the attentional bias characteristic of individuals with IGD. The addiction Stroop paradigm and the visual probe paradigm were used to measure differences in attentional bias traits between IGD and HC participants. In this study, no significant differences in attentional bias characteristics were found in IGD participants compared to HC participants. However, in the exploratory study using the newly developed single-image inconsistent version of the Dot-Probe Paradigm, IGD participants exhibited attentional bias characteristics compared to HC participants.

In this study, adapted versions of the addiction Stroop task and the Dot-Probe Paradigm were used as measurement paradigms for attentional bias in IGD. For substance addiction, attentional bias is an important trait, and both the addiction Stroop and Dot-Probe Paradigms are classic paradigms for measuring it. In previous research on attentional bias traits in substance addiction, these paradigms have successfully measured attentional bias towards substance-related cues. However, in the field of behavioral addictions, particularly IGD, measurements of attentional bias have yielded inconsistent results. Metcalf found attentional bias in IGD using the addiction Stroop task; Lorenz found attentional bias towards gaming cues in IGD using only the Dot-Probe Paradigm [12]; Van Holst found no specific attentional bias towards gaming cues in IGD using either the visual probe or addiction Stroop tasks [13]. Unlike the stable measurement of attentional bias traits in substance addiction, the heterogeneity of attentional bias observed in IGD highlights differences between IGD and substance addiction. There are two possible reasons. First, online gaming can enhance users' reaction speed and selective attention, which might affect reaction time measurements, potentially causing IGD participants to react faster in RT tasks, leading to a ceiling effect. Second, gaming cues, especially game pictures used as stimuli in attentional bias tasks, are inherently highly attractive. Compared to the relatively mundane neutral household item stimuli, they might capture the attention not only of IGD individuals but also of HC participants. This could be another reason why IGD participants did not show significant attentional bias towards gaming cues. For the addiction Stroop task using common gaming words and neutral household words, IGD participants showed longer reaction times to gaming words than neutral words, indicating attentional bias. However, the same difference appeared in the HC group. For HC participants, gaming words are less common and less frequently encountered in daily life compared to household words. This novelty effect could lead them to allocate more attentional resources to gaming words, potentially explaining the lack of significant difference in attentional bias scores between the groups.

5. Conclusion

This study conducted an exploratory investigation of the Dot-Probe Paradigm by deconstructing its influencing factors into three simplified versions. The results showed that in the single-image inconsistent version, compared to the traditional Dot-Probe Paradigm version, IGD participants demonstrated a significant attentional bias towards gaming cues relative to HC participants. This suggests that the single-image inconsistent Dot-Probe Paradigm could serve as a relatively sensitive attentional bias measurement tool.

This study did not measure attentional bias towards gaming cues in IGD participants using the addiction Stroop paradigm and the traditional Dot-Probe Paradigm, potentially due to the specificity of gaming cues. For healthy controls who play games infrequently or not at all, compared to common household words and pictures, gaming-related words and colorful, exquisitely designed game pictures are novel, specific stimuli. This novelty likely attracts more attention from HC participants, leading to their longer reaction times to gaming cues.

6. Limitation

In the exploratory visual probe study, although a significant difference in attentional bias scores between HC and IGD groups was found in the single-image inconsistent version, the sample size was small, and the effect size was modest. Larger sample studies are needed to further validate the effectiveness of this exploratory Dot-Probe Paradigm in measuring attentional bias.

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