Original article

Attentional Bias and Disinhibition Toward Gaming Cues Are Related to Problem Gaming in Male Adolescents

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A B S T R A C T

Purpose: The aim of this study was to examine whether behavioral tendencies commonly related to addictive behaviors are also related to problematic computer and video game playing in adolescents. The study of attentional bias and response inhibition, characteristic for addictive disorders, is relevant to the ongoing discussion on whether problematic gaming should be classified as an addictive disorder.
Methods: We tested the relation between self-reported levels of problem gaming and two behavioral domains: attentional bias and response inhibition. Ninety-two male adolescents performed two attentional bias tasks (addiction-Stroop, dot-probe) and a behavioral inhibition task (go/no-go). Self-reported problem gaming was measured by the game addiction scale, based on the Diagnostic and Statistical Manual of Mental Disorders-fourth edition criteria for pathological gambling and time spent on computer and/or video games.
Results: Male adolescents with higher levels of self-reported problem gaming displayed signs of error-related attentional bias to game cues. Higher levels of problem gaming were also related to more errors on response inhibition, but only when game cues were presented.
Conclusions: These findings are in line with the findings of attentional bias reported in clinically recognized addictive disorders, such as substance dependence and pathological gambling, and contribute to the discussion on the proposed concept of "Addiction and Related Disorders" (which may include non–substance-related addictive behaviors) in the Diagnostic and Statistical Manual of Mental Disorders-fourth edition.
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Computer and video games are popular forms of entertainment for many adolescents around the world. For the vast majority of them, gaming provides nothing but positive and enjoyable experiences. However, some adolescents become so captivated that they tend to spend excessive amount of time playing and are unable to control their excessive gaming habits despite detrimental social and emotional consequences [1,2].

Deciding when someone's gaming behavior can be seen as "excessive" is not straightforward, and no conceptual consensus is present on "gaming addiction," or "pathological (video) gaming" [3,4]. Several researchers consider excessive or problem gaming to be a type of behavioral addiction similar to pathological gambling, and have adapted the typology of diagnostic criteria for pathological gambling from the Diagnostic and Statistical Manual of Mental Disorders-fourth edition (DSM-IV) [5],

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so as to further explore and quantify the concept of problematic gaming [6,7]. Several studies have indicated that problematic computer game playing shares several diagnostic criteria with recognized addictive disorders, including craving, loss of control over gaming, withdrawal symptoms, preoccupation, and relapse [1,8,9]. As a result, some argue in favor of a unified concept of "Addiction and Related Disorders" spanning both substance and behavioral addictions, in the upcoming fifth edition of the DSM. However, although frequent gaming has been associated with improvement of performance on tasks measuring speeded visual and attentional abilities [10,11] in which responses have to be made as fast as possible, neurocognitive performance decrements have been found in substance-dependent persons and pathological gamblers [12,13]. Considering the similarities in symptoms between recognized addictive behaviors and problematic gaming, the purpose of the present study is to investigate whether behavioral aspects commonly associated with addictions are consistent with those observed in problematic gaming. Clarifying whether problematic gamers display behavioral tendencies as consistently found in addiction disorders will contribute to the ongoing discussion on comparability with other non–substance-related addictive disorders.

It is well known that persons with an addictive disorder automatically allocate attention to addiction cues in the environment, a process referred to as attentional bias [14]. Attentional bias for addiction cues is thought to result from acquired motivational and attention-grabbing properties of these cues because of the sensitization of the motivational system in the brain [15]. Using attentional bias tests, such as the addiction-Stroop task [16] or the dot-probe task [17], evidence of attentional bias toward addiction-related stimuli has been found in a variety of addictive disorders [18–20]. To date, three studies have investigated the role of attentional bias in problematic adult gamers. In the first study, responsiveness to game-related cues in excessive (22.5 hr/wk) and occasional (1.25 hr/wk) game players was examined [21]. Electroencephalogram analyses of excessive players indicated that they were significantly more sensitive to game-related cues than occasional players. A functional magnetic resonance imaging study on cue-reactivity in problematic gamers indicated that neural substrates of cue-induced craving among problem gamers resembled the cue-induced craving in substance dependence [22]. A behavioral study on attentional bias in frequent and infrequent World of Warcraft (WoW) players reported enhanced attention to WoW words and faster response times in frequent WoW players compared with infrequent players [23].

These findings strengthen the notion that similar cognitive processes such as enhanced attention to addiction-related cues implicated in other addictive disorders might also present in adults who display signs of problematic gaming. However, it is unclear whether these processes are also present in younger individuals, that is, problematic adolescent gamers. In addition, because attentional bias has been related to relapse in addictive behaviors [24,25], and problematic game playing usually starts during adolescence [26], it is essential to know whether attentional bias is already present in this age group.

A second behavioral domain associated with addictive disorders is diminished self-regulation, as manifested in a diminished ability to withhold motor responses (e.g., responding with a button press when a stop signal is given) [13,27]. Using tasks, such as the go/no-go task [28] or stop signal task [29], diminished response inhibition has been found in addictive behaviors [30–

32]. One study reported diminished response inhibition in adult gamers compared with less frequent gamers [23]. To our knowledge, studies examining response inhibition in adolescent gamers have not been published.

Therefore, the purpose of the current study was to investigate the relation between (a) attentional bias and (b) response inhibition and the continuum of problematic gaming in adolescents. If these behavioral patterns, which are commonly associated with addictive disorders, are also related to problem gaming levels, this could provide evidence that underlying cognitive-emotional processes of addictive disorders are also relevant for problem gaming, adding to the discussion on the conceptualization of problem gaming as an addictive disorder.

For clarity, we will use the term "level of problem gaming" in the remainder of the article to indicate that we measured gaming problems on a continuous scale. We investigated whether performance on attentional bias and response inhibition tasks was associated with participants' level of problem gaming, as measured with the game addiction scale for adolescents developed by Lemmens et al [7]. Based on previous studies in adult gamers [21–23], we hypothesized that a positive relation between scores on the game addiction scale and attentional bias for game cues in adolescent gamers would be present. We also hypothesized that higher problem gaming levels would be associated with more errors on response inhibition in adolescent gamers, based on evidence of diminished response inhibition in addictive disorders [13,27].

Participants

We recruited a sample of adolescents from six different Dutch high schools, from a larger study investigating gaming [7]. Their age ranged from 12 to 17 years (mean = 15.1 years, SD = 1.27). To ensure that sufficient regular and heavy gamers would be included in the current study, only male participants who had engaged in some form of video gaming in the month before the current study were invited to volunteer. Male adolescents were included because they are more likely to play games excessively and are more prone to experience negative consequences because of their gaming behavior [9,33,34]. When the participants in the current study were compared with the nonparticipating male adolescent gamers from the aforementioned survey, it was found that our sample of volunteers spent more time on computer or video games (t [349] = −6.09, $p < .001$), and they showed higher levels of problematic gaming as measured by the game addiction scale described later in the text (t [349] = −7.64. $p < .001$). No significant differences in age were found between the samples. This indicates that––as expected–– our participants overall were heavier gamers who showed relatively more signs of problem gaming compared with a general sample of Dutch adolescent game-playing boys [7]. This study was approved by the ethical review board of the University of Amsterdam. Before participation, we obtained informed consent from participants, their parents, and their schools.

Procedure

During school hours, participants were taken in pairs to an empty classroom where they were each seated behind a laptop, facing away from each other. For each test, separate verbal instructions were given, and practice trials were included. All tests were run on a laptop and were developed using E-Prime [35]. The

Table 1
Mean differences in time spent on games, attentional bias, and response inhibition

Subgroups of three problematic gaming levels	Game addiction*	Age	Time Hr/wk Games*	Attentional bias tasks							Response inhibition task	
				Dot-probe				Addiction-stroop			Go/No-go	
				General RT (msec)	RT-bias (msec)	Errors on animation pictures*	Errors on game pictures	Errors on game words*	Errors on animation words	RT-bias (msec)	Basic condition inhibition errors	Game condition inhibition errors*
Low (N = 31)												
M	1.38	14.09	7.25	330.41	−.84	1.61	2.00	−1.11	4.90	5.50	6.43	5.74
SD	.27	.32	7.19	40.67	12.31	1.71	2.29	2.98	3.34	55.55	4.52	3.24
Medium (N = 31)												
M	2.04	15.43	14.22	321.72	.99	2.38	1.90	.17	5.28	4.14	7.62	6.63
SD	.15	1.35	8.58	32.39	14.05	2.40	1.68	3.55	3.41	43.85	4.76	3.97
High (N = 30)												
M	2.71	14.97	22.17	313.91	−.99	3.25	3.09	.37	6.47	−7.48	7.58	7.35
SD	.28	1.43	16.15	26.41	10.87	2.27	2.84	3.20	3.03	51.06	4.69	3.70
Total (N = 92)												
M	2.12	15.06	14.47	322.10	−.27	2.42	2.35	−.19	5.54	.65	7.20	6.56
SD	.56	1.40	12.72	34.05	12.39	2.22	2.38	3.29	3.30	50.31	4.69	3.67

Errors = incorrect responses to neutral cues and game cues; RT-bias = mean difference in reaction times between neutral cues and game cues.

* A significant correlation of at least $p < .05$ between pathological gaming scores and the dependent measure.

order of tests was counterbalanced between pairs of participants. When both participants had completed all three tests, they were asked to fill out a paper-and-pencil questionnaire. This questionnaire contained a scale to measure problematic gaming (i.e., game addiction scale) [7], and items on time spent playing games in the 6 months before the study.

Self-Report Measures

Game addiction scale

To measure respondents' level of problematic gaming, we used the 21-item *game addiction scale* [7], based on DSM-IV-criteria for pathological gambling as previously adapted by Griffiths [6]. This scale included three items for each of the seven underlying criteria of pathological gaming: *Salience, Tolerance, Mood modification, Relapse, Withdrawal, Conflict*, and *Problems*. Every item was preceded by the statement: "During the last six months, how often . . . ." Players rated all items on a five-point scale: 1 (*never*), 2 (*rarely*), 3 (*sometimes*), 4 (*often*), 5 (*very often*). This 21-item scale showed good reliability with a Cronbach's alpha of .89. Total scores ranged from 21 to 105, with scores per item from 1 to 5. To facilitate the interpretation of the scores on this scale, we report individual mean scores (i.e., total scores divided by 21 [the total number of items]). Thus, scores of the game addiction scale in Table 1 could range from 1 to 5.

Because it is increasingly believed that mental and behavioral disorders can best be understood as points along a continuum [36], we conceptualized problematic gaming as a continuum, instead of using an arbitrary cut-off point to distinguish problem gamers from "normal" gamers. To be able to indicate the distribution in scores within the sample, we also created three groups based on the 33rd and 67th percentiles of the self-report game addiction scale: low problem gaming scores (N = 31), medium problem gaming scores (N = 31), and high problem gaming scores (N = 30).

Time spent on games

We measured weekly time spent on computer and video games by multiplying the number of days per week indicated by the participants by the number of hours per day indicated by participants as spent on specific platforms (i.e., personal computers, consoles, handheld gaming devices).

Attentional Bias Measures

Dot-probe task

A game picture and a matched neutral animation picture were simultaneously presented, left and right of a fixation point ("+") in the middle of a computer screen [17]. Participants followed the on-screen instructions to focus on this fixation point. After 10 neutral practice trial runs with feedback, they were presented with the actual task. Each of the 50 pairs of pictures was shown twice (once left and once right of the fixation point). The order in which the pairs were shown was randomized across participants. Pictures appeared for 500 ms after which they disappeared, revealing a small rectangular probe behind one of the pictures for 200 ms. Participants were instructed to press the left key (Z-key on the keyboard) when the probe appeared left, and to press the right key (M-key on the keyboard) when the probe appeared right.

The game pictures were all in-game screenshots from 18 console and computer games that were selected according to the most popular titles among adolescent boys, as reported in the survey of a previous study [7] from which participants were recruited (e.g., Call of Duty, Counter-Strike, WoW). Neutral pictures consisted of animated cartoons from popular film and television characters, not present in any computer or video games. All pictures were pretested for salience in a group of undergraduate students who engaged in video gaming regularly, after which outliers in attractiveness or pictures associated with gaming were removed.

The dependent measures of attentional bias for game cues were as follows: (1) reaction time bias (RT-bias) and (2) error bias. RT-bias refers to faster responses to probes that follow game pictures than to those that follow (neutral) animation pictures. This RT-bias was calculated by subtracting RTs to probes behind game pictures from RTs to probes that appeared behind animation pictures. A positive score indicates a tendency to react faster to probes that appear at the location of the game pictures compared with probes at the location of the animation pictures, thereby inferring attentional bias. The error bias was measured by the number of erroneous responses toward probes behind animation pictures (i.e., responding toward the location of the game picture, when the probe was presented behind the animation picture).

Addiction-stroop task

We used a modified version of the addiction-Stroop task [16]. Thirty-four words were successively presented on a screen. Participants were asked to indicate the font-color of the presented word. They pressed "1" for green, "2" for red, and "3" for blue. All 34 words were randomly presented three times, each time in a different font color. We used 17 game-related words and 17 non–gaming-related words that were matched on word length and phonetic structure. For instance, we matched *Warcraft* with *Worldcup,* and *Multiplayer* with *Mediaplayer.* After each font color selection, participants received feedback on their response correctness, total percentage of correct responses, and RT.

Attentional bias was inferred in two ways: (1) RT-bias and (2) number of errors during game-related words. RT-bias was measured by calculating the RT to game-related words minus the RT to movie-related words. A positive score on RT-bias indicates slower response times to game-related words compared with movie-related words, thereby indicating attentional bias [16]. The number of errors to game-related words reflects the attentional bias due to heightened attention to processing the semantic content of game-related words, which results in higher error rates.

Response Inhibition Measure

Go/no-go task

Our go/no-go task consisted of two conditions, a basic motor inhibition condition and a game condition, measuring inhibition to game cues. In the basic condition, participants were presented with 120 pictures of animals and 40 pictures of humans. They were asked to press the spacebar as fast as possible only when presented with a picture of an animal. All pictures appeared for 800 ms and were semi-randomized, so as to prevent two consecutive no-go pictures.

In the game condition, 120 pictures of cars and 40 pictures related to games were presented. Participants were instructed to press the spacebar as fast as possible when confronted with a picture displaying a car, and to withhold a response when a picture of a game was displayed. No pictures of race cars, race games, or other game-pictures displaying cars were used. The dependent measures of basic and game-related response inhibition were the number of responses to no-go pictures during the basic and the game condition. More errors (i.e., responding to no-go pictures) indicated more disinhibition [28].

Statistical Analysis

Any responses <100 ms and individual scores larger than three standard deviations above or below the overall mean of a particular dependent measure were considered outliers and were removed from further analysis [37]. Individual mean RTs were based solely on correct responses. We examined the Spearman correlation between individual mean scores on the game addiction scale and measures of attentional bias and response inhibition (all tested two-sided, $p < .05$). All analyses were performed using SPSS 16 [38].

Results

Descriptive results

Individual mean scores on the addiction gaming scale ranged from 1.00 through 3.43 (mean = 2.12, *SD* = .56). For display purposes, using the 33rd and 67th percentiles as the cut-off points, we divided participants into three groups as follows: low problem gamers (mean range: 1.00–1.86, N = 31), medium problem gamers (mean range: 1.86–2.33, N = 31), and high problem gamers (mean range: 2.33–3.43, N = 30) (Table 1). There was no significant correlation between the addiction gaming scale score and age, and no age differences between the three groups were present. Participants' weekly time on computer and video games ranged from 10 minutes to 54 hours (mean = 14.47, *SD* = 12.72). As expected, time spent on games correlated with the scores on the addiction gaming scale ($r = .49$, $p < .001$; see Table 1).

Dot-probe results

The mean overall RT to all probes (the animation and game probes aggregated) was 322 ms (see Table 1). The correlation between participants' game addiction scores and RT-bias was not significant ($r = .03$, $p =$ not significant). There was, however, a significant correlation between game addiction scores and type of errors: more errors were made toward the location of gaming pictures when the probe appeared behind the animation pictures ($r = .25$, $p = .03$), indicating an attentional bias toward the game pictures among players with higher levels of problem gaming.

Addiction-stroop results

One participant was removed from analysis because of a high number of errors resulting because of color blindness. Participants' game addiction scores were significantly correlated with amount of errors for game-related words ($r = .23$, $p < .05$). We found no correlation between the game addiction scores and RT-bias of the participants ($r = .00$, $p =$ not significant).

Go/no-go results

Data from two participants were removed as outliers with 48 and 50 counts of failed inhibition (> 3 SDs from the mean). In the basic condition (go animals, no-go humans), participants' mean game addiction scores were not significantly correlated with the number of failed no-go trials ($r = .16$, $p =$ not significant). However, in the game condition (go cars, no-go games), participants'

game addiction scores were significantly correlated with the number of failed no-go trials ($r = .27$, $p < .01$; see Table 1).

Discussion

This study investigated whether attentional bias and response inhibition are related to levels of problem gaming in adolescents, so as to discover whether behavioral patterns commonly associated with addictive disorders are also related to levels of problem gaming.

We hypothesized to find a positive correlation between level of gaming problems and gaming-related attentional bias and we found mixed evidence for this. We did not find an association between RT-bias and self-reported levels of problem gaming in the dot-probe task and in the Stroop task. We did find a positive relation between self-reported levels of problem gaming and error-bias to game picture locations in the dot-probe task. This error bias toward the location of the gaming picture is indicative of attentional bias toward game pictures. Congruently, higher levels of problem gaming were related to higher number of errors in the game condition in the Stroop task. This suggests preoccupation with addiction-related information, which compromises correct color naming, thereby indicating attentional bias [16].

We also hypothesized that higher scores on the game addiction scale would be related to diminished inhibition (higher number of commission errors in the go/no-go task) [13,27]. Interestingly, we found a relation between commission errors and levels of problem gaming during the gaming go/no-go condition, but not during the neutral go/no-go condition (basic inhibition). Thus, in an inhibition task encompassing gaming cues, disinhibition toward gaming pictures is related to higher levels of gaming problems in adolescent boys. In real life, these findings could imply that, because of their preoccupation with game-related cues, gamers with higher levels of problem gaming may have more difficulty restraining from starting a game when they should be doing other things on their personal computer, or disengaging from a gaming session once started. Impulsivity is a behavioral feature that plays an important role in the development of addictive disorders. Several addiction models have postulated that engaging in addictive behaviors results in an imbalance of enhanced appetitive processes (attentional bias toward addiction cues) and weaker executive control over these appetitive processes, thereby leading to loss of control over addictive behavior [39].

Contrary to previous studies in adults on attentional bias in problem gaming where a division in groups was made [21,22] between "game addicts" and "non-addicts," we focused on a continuum of self-reported problem gaming. Our sample differed from previous studies in age and history of problematic gaming [21–23], but we obtained similar results of increased attention toward game-related stimuli in adolescent participants. Thus, attentional bias toward game cues can also be found in subclinical adolescent gamers. Longitudinal studies are needed to investigate the causal role of attentional bias in the development of problematic gaming.

We used computerized behavioral tasks that are effective in determining attentional bias in addictive disorders [14,19,20]. Contrary to the findings in these studies, RT-bias to game cues showed no significant correlation with levels of problem gaming. This may be related to floor effects because our participants responded very fast compared with RTs usually encountered in adult substance-dependent samples [17]. In addition, all our behavioral tasks required actions that are strongly related to computer and video game skills. Several studies have shown that computer games can improve players' abilities related to motor skills and selective attention [10,11], and this may have confounded the RT-related dependent measures.

A limitation of our study is that we tested a convenience sample of adolescents in which we could not control for the games played by our participants. Differential relevance of certain game-related stimuli may thus have reduced sensitivity to identify attentional bias. In addition, we cannot ignore the fact that our results were influenced by an interaction with individual characteristics such as stage of brain maturation and cognitive capacity, aspects that can play a role in attentional bias and response inhibition measures [39]. Furthermore, our study used self-report data, which carry the risk of response bias, such as under-reporting of problems [40].

In conclusion, self-reported levels of problem gaming in adolescent gamers are associated with error-related attentional bias for game cues and diminished gaming-related inhibition. This indicates that behavioral patterns commonly associated with addictive disorders are also related to problem gaming. Thus, our findings suggest that given the presence of attentional bias, problem gaming has similarities to substance dependence and pathological gambling with regard to underlying cognitive-motivational mechanisms. This may provide an argument to consider the classification of problem gaming alongside pathological gambling. However, similarities in attentional bias only provide evidence regarding one aspect relating to addictive disorders, and evidence from epidemiological, neuroimaging, and treatment studies should also be included in this debate.

Future research should establish in what way attentional bias is related to the development of problematic gaming, and whether it can be used as a vulnerability marker for the course of problematic gaming.

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