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Why We Can't Stop: The Impact of Rewarding Elements in Videogames on Adolescents' Problematic Gaming Behavior

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ABSTRACT

This study explored the association between rewarding elements in videogames and adolescents' problematic gaming behavior, evaluating the extent to which individual vulnerabilities amplify this relationship. In a two-cohort-design the impact of rewarding elements on adolescents' problematic gaming was investigated: the first cohort consisted of 2708 secondary school students (53.9% male, $M = 13.9$ SD = 1.20), and the second cohort of 1616 (54.2% male, $M = 14.7$ SD = 1.28). As the type of games that participants were playing differed over time, the second cohort was treated as a replication of the first one. Results revealed that random, social, and contingencies rewards were associated with adolescents' problematic gaming in both cohorts. Games including these rewards were associated with an increased risk for problematic game-play. Moreover, results indicated that the association between contingencies rewards and problematic gaming behavior was stronger for adolescents with attention-deficit /hyperactivity disorder symptoms, while the association between social rewards and problematic gaming was stronger for adolescents with social problems. This study contributed to our understanding of the mechanisms that can explain why certain adolescents, particularly those with ADHD and/or socially vulnerable, are riskier to develop problematic gaming. These insights can contribute to a more tailored prevention and treatment approach aiming at problematic gaming among adolescents.

Introduction

Game playing has become one of the main leisure activities of adolescents in many developed countries and it is prevalent across many cultures (Elmezeny & Wimmer, 2018; Muriel & Crawford, 2020). Unfortunately, like many other highly rewarding activities, a minority of gamers pursue the activity in such an excessive and uncontrolled manner that the behavior becomes problematic or addictive. Despite ongoing scholarly discussion regarding the definition of problematic gaming (Griffiths, Kuss, Billieux, et al., 2016; Kardefelt-Winther,

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2015; van Rooij et al., 2017), one set of factors that seems to be central to understanding the development of problematic gaming encompasses the structure, components, and elements of the video games themselves (Griffiths et al., 2012; D. King et al., 2011; D. L. King et al., 2010; Kuss & Griffiths, 2012a, 2012b). As games are products of a profit-oriented industry, the objective of game developers and publishers is to create attractive and enjoyable games that are played by as many gamers as possible, for as long as possible, to maximize their gains. Integrating different types of rewards within a game is a way to maximize these profits. To ensure continuous play, developers make use of knowledge about psychological mechanisms that promote the continuation of certain behaviors, such as operant conditioning via variable-ratio reinforcement schedules, that promote player investment on a long-term basis (Charlton & Danforth, 2007; D. L. King et al., 2010).

Common Rewards in Current Videogames

Most rewards in games are delivered on variable ratio (=random) schedules. For instance, in a fantasy role playing game, players may find a valuable sword only in 1% of the enemies they defeat. Existing literature has shown that variable-ratio reinforcement produces the most consistent and steady response and is the least susceptible to extinction (e.g., quit playing a game) (Haw, 2008; Hurlburt et al., 1980; Peele et al., 1984; Zuriff, 1970). One example of this mechanism is the use of "loot boxes" in videogames; this type of reward shows similarities with gambling principles as it is often unclear how likely certain items can be earned within the game and because high-end items are difficult to win (Griffiths & King, 2015).

Furthermore, many successful games have a repeat log-in bonus, named contingencies rewards, which rewards players with a free reward of virtual goods every day they log-in (Johnson et al., 2018). These bonuses leverage a well-known principle of behavioral economics (Butler, 2015): operant conditioning of a given behavior by positive reinforcement, in this case, increasing logins by associating them with a reward (e.g., a free gift of in-game goods). While claiming the reward, users associate the positive feedback with the log-in behavior and tend to associate this positive feeling with the game. As a result, users log into the game more frequently and play more often (Hursh, 1984; Skinner, 1969; Staddon & Cerutti, 2003). Today, we can see an evolution of these mechanics; some games go beyond a simple daily reward cycle, offering a tiered reward for both cumulative and consecutive log-ins. For instance, in the game Fortnite, players who log-in up to 2 consecutive days would receive a "common" reward, but after logging in 3 to 6 days, earn a chance to win an "uncommon" reward, and as of 7 days, the chance to win a "rare" reward. The idea behind these progression mechanics is simple: the more engaged users are in the game, the greater they will be rewarded.

Another games feature conceives to encourage players to continue playing is meta-achievements. This rewarding schedule is designed to give players an overall assessment of their mastery over a video game. In some games, this mastery is represented by a single percentage rating that indicates how much of the game the player has completed. Recent advanced examples of meta-game rewards include the Xbox's Achievement Point system and the Playstation's Trophies one (Jakobsson, 2011). Through these systems, players are rewarded for accomplishing the varied requirements on a game's list of specific achievements. Achievement points are designed to keep the player involved with the video game after the game has been completed, either by replaying the game or playing the game online (Cruz et al., 2017).

Finally, social aspects of playing are important and influence gameplay (Halbrook et al., 2019; Kaye & Bryce, 2012). The opportunity to construct friendships, compete with other players, build communities, and engage in social interactions in the virtual world, is rewarding for players and is often stated as one of the reasons for the increasing popularity of online videogames (Elliott et al., 2012; Floros & Siomos, 2012; Ghuman & Griffiths, 2012; Männikkö et al., 2017; Saint Sferra et al., 2017). Players want to interact with friends and to keep up with their social connections through videogames. Moreover, these social interactions are sometimes rewarded as team play is often essential to win the game, particularly in online games. Previous research has demonstrated that people spend more time on gaming and get more engaged in games activities to receive social rewards (Hou, 2011; Wei & Lu, 2014).

In video games, reward systems can keep players interested and entertained over the course of a game (Hallford & Hallford, 2001). Although the direct function of any reward is to provide a goal, a well-designed reward mechanism can push players to continue gaming by enhancing positive gaming experiences and motivations. Previous studies have shown that video game rewards effectively motivate players gaming behaviors by enhancing feelings of fun and enjoyment (Lee et al., 2003; Sansone & Smith, 2000; Vorderer et al., 2004). Moreover, rewarding mechanisms in games are tied to underlying motivational needs of gamers such as the need for competence (challenges and progression), autonomy (freedom of choice and interaction), and relatedness (affiliations with others), as the inherent experiences create intrinsic motivation to a player (Przybylski et al., 2010). For instance, Bowey et al. (2015) investigated the impact of leaderboards, finding that higher leaderboard positions increased players' perception of competence, autonomy, presence, enjoyment, and positive affect compared to lower leaderboard positions. Furthermore, achievement systems and status indicators are reward mechanisms that provide additional goals for players, supporting feelings of relatedness through social connection, cooperation, and competition (Bleumers et al., 2012; Ryan et al., 2006).

However, these rewards may have more extreme effects among specific players with certain individual vulnerabilities. Previous studies have shown that games' reward systems contribute to problematic gaming behavior, particularly among individuals who have individual vulnerabilities such as difficulties with self-regulation and impulse control (D. L. King & Delfabbro, 2009; Kuss et al., 2014; Männikkö et al., 2017). It is therefore possible that these players are more sensitive to specific rewarding mechanisms in games, which could contribute to the development and maintenance of problematic gaming. In this study, four reward types (random rewards, contingencies rewards, meta-achievements rewards, and social rewards) are examined in relation to problematic game play to increase. our understanding of the mechanisms that may underlie the transition from recreational to problematic game play.

Individual Vulnerabilities and Videogames Playing

Existing literature has highlighted how specific individual vulnerabilities appear to be related to developing problematic gaming behavior (Choo et al., 2010; Kowert, 2014; McKelvey, 2012; Mentzoni et al., 2011). Individual vulnerabilities such as a lack of behavioral control or difficulties with social relationships could amplify the perceived rewarding effects of certain games and consequently increase the impact of these rewarding elements (D. L. King & Delfabbro, 2020; Naskar et al., 2016). According to the Differential Susceptibility to Media effects Model (DSMM; Valkenburg & Peter, 2013), individuals may have varying levels of susceptibility to media effects due to their individual differences. This susceptibility is theorized as a multifaceted construct that includes dispositional (e.g., existing hostility or aggression), developmental (e.g., age of child or developmental maturity), and social (e.g., parental media monitoring or peer culture) susceptibility (Piotrowski & Valkenburg, 2015). Individual responses to the media use are thus affected by dispositional, developmental, and social-context differences among media users (Kuss et al., 2014). In the context of video games, individual vulnerabilities might affect the responses on game rewards. Rather than affecting players uniformly, rewards mechanisms may increase problematic gaming behavior most strongly among adolescents with certain psychosocial vulnerabilities.

There is growing evidence for an association between problematic game play and attention-deficit/hyperactivity disorder (ADHD) (Dullur et al., 2021; Mathews et al., 2019; Weinstein & Weizman, 2012). Previous studies have shown that individuals with attention problems are assumed to engage in excessive gaming behaviors more due to their difficulty to redirect their attention to long-term goals, thereby allowing gaming to be their main source of achievement and satisfaction (Milani et al., 2018; Peeters et al., 2018, 2019). These factors, alongside poor impulse control (that is often co-present with attention problems), may impede disengagement from the continuously

rewarding stimuli embedded in videogames (Anderson et al., 2017; Stockdale & Coyne, 2018; Yen et al., 2009). Similarly, it has been shown that impulsivity is another important factor underlying problematic game play (Ding et al., 2013; Ko et al., 2015). Adolescents who have difficulties controlling their behavior are particularly sensitive to rewarding behaviors (Dong et al., 2017; Peeters et al., 2017). Reward mechanisms in games, such as time-limited rewards (i.e., rewards that are only available for a certain amount of time), may initiate positive gratification and may particularly challenge impulsive adolescents in withstanding the rewarding effects of game behavior (Joseph, 2021). Moreover, loss of control in gaming is an essential criterion of internet gaming disorder (Petry et al., 2014), thereby indicating that high impulsivity could increase vulnerability to problematic gaming behavior.

Furthermore, when it comes to social functioning previous studies have considered social anxiety, low self-esteem, and autistic spectrum problems in relation to problematic gaming (Bhagat et al., 2020; Craig et al., 2021; Cudo et al., 2019; Karaca et al., 2020). In their study, Li et al. (2018) reported that excessive game use is motivated by cyberspace social encounters in individuals with poor offline social support, including support from family members. Furthermore, adolescents with diminished social competences may spend more time on gaming, as gaming may be an area in which they experience fewer social demands, more social connectedness, greater mastery and an escape from their daily struggles in the face-to-face social world (Przybylski, 2014; Shen & Williams, 2011). Thus, players with problems regarding their social competencies may be specifically sensitive to the socially rewarding effects of certain games (Cole & Griffiths, 2007; Lobel et al., 2014).

While studies suggest a link between individual vulnerability and problematic gaming, as far as we know, no previous research has tested whether these vulnerabilities (ADHD symptomatology and lowered social competence) amplify the possible impact of (particular) rewarding mechanisms in games on the development of problematic game play. Therefore, the current study aims to investigate the association between rewarding elements in games and problematic gaming behavior, and the moderating role of individual vulnerability markers such as ADHD and perceived social competence in a sample of young adolescents. In line with previous research on problematic gaming (Carras et al., 2017; D. L. King et al., 2019; Nakayama et al., 2020), the present study will adopt a continuous measure of problematic game play, instead of using a cutoff value.

The present study

Currently, games are more advanced than ever and rewarding elements in games become more and more sophisticated, thereby possibly increasing the risk of problematic gaming among vulnerable youth. However, to date, previous studies on reward-related mechanisms in relationship to problematic

gaming have primarily relied on (young) adult samples, mostly ignoring adolescence as a critical period for the development of problematic gaming behaviors (Milani et al., 2018; Spekman et al., 2013). Insights on rewarding game elements that particularly tend to promote problematic game play in vulnerable youth can help to identify the games that are riskier due to embeddedness of certain rewarding elements. The present study aims to fill this gap in the existing literature by, first, identifying the role of different in-game reward types in predicting problematic gaming, and second, testing the moderating role of players' individual vulnerabilities within the association between in-game reward types and problematic gaming. This leads to the following research questions:

(1) Are certain rewarding gaming elements associated with problematic game play?
(2) Do individual vulnerabilities (attentional disorder, impulsivity, hyperactivity, social competence) amplify the association between certain rewarding game features and problematic game play?

Methods

Sample and Procedure

Data for this study were collected as part of the Digital Youth Project, a longitudinal study that monitors trends in online and gaming behavior of young Dutch adolescents. Adolescents were recruited from secondary schools in the Netherlands, and they were followed across multiple waves, with one-year intervals between waves. For this study, wave 3 (2017) and wave 4 (2018) were used (now referred to as Cohort1 and Cohort2). Although the project collected longitudinal data, both the data of Cohort1 (C_1) and Cohort2 (C_2) were analyzed separately as the type of games that were played differed between these waves, and thereby also the exposure to rewarding elements (e.g., Fortnite was very popular in 2018, whereas it was not yet launched in 2017). To avoid issues related to possible clustering during data analysis, participants who participated in both measurement waves were exclusively selected for the first cohort (C_1). In this way, the second cohort (C_2) was used as a replication sample for our study, thus consolidating our results.

Only adolescents who were recent game players (in the last 3 months) were included in the sample. The 2017 cohort (C_1) sample consisted of 2708 participants (53.9% male) with ages ranging between 11 and 17 years (M = 13.94, SD = 1.20). Most participants (80.9%) had a Dutch background (they and both their parents were born in the Netherlands). Adolescents were enrolled in different educational tracks, with 62.7% in vocational education programs and 37.4% in college or university preparatory programs. The 2018

cohort (C_2) sample consisted of 1616 participants (54.2% male) with age between 11 and 18 years ($M = 14.70$, SD = 1.28). Most participants (89.3%) had a Dutch background. Adolescents were enrolled in different educational tracks, with 50.3% in vocational education programs and 49.7% in college or university preparatory programs.

At each wave, adolescents completed an online survey in their class during regular school hours. Research assistants were present to supervise the data collection. Respondents were informed that participation was voluntary and that they could stop participating at any time. Moreover, it was emphasized that responses would be treated with great confidentiality. In addition, at each measurement wave, parents were informed about the content and aim of the study, and they could refuse the participation of their child by withholding informed consent. The study procedures adhered to the Declaration of Helsinki and were approved by the ethical board of the Faculty of Social Sciences at Utrecht University.

Measures

Rewards in games

Respondents were asked, with an open-ended question, which video game they had played most in the past 3 months. Based on the total list of video games reported by participants ($n = 186$), a group of four research assistants with knowledge about games independently coded the games, after reviewing the video games' game-play and/or playing it oneself, with respect to the following four categories of rewards: random rewards, social rewards, contingencies rewards, and meta-achievements (0 = *Absence*, 1 = *Presence*). Games could receive more than one code and thus entail more rewarding elements than only one (see Table 3 for examples). Each video game was coded based on the presence of these four features by the four coders (random rewards $\kappa = 0.92$; social rewards $\kappa = 0.94$; contingencies rewards $\kappa = 0.91$; meta-achievements $\kappa = 0.87$) and disagreements between coders were handled through an open-ended discussion in order to obtain a final codification to use for the study. Next, all participants received an individual score on all four reward.

Attention-deficit hyperactivity disorder

ADHD problems were assessed using the ADHD Questionnaire (Scholte & Van der Ploeg, 2007). The scale includes three subscales that provide information about perceived ADHD problems: attention problems, impulsivity, and hyperactivity. The three subscales included nine items for attention (e.g., "I have little attention for details and tend to make unnecessary mistakes"), six items for impulsivity (e.g., "I find it difficult to wait for my turn"), and six items for hyperactivity (e.g., "I feel restless") on a 5-point scale ranging from 1

= *Never* to 5 = *Very often*. Mean scores of each subscale were calculated and used as a measure of attention problems, hyperactivity, and impulsivity, with higher scores indicating more problems. Cronbach's α for attentional problems was .87 for C_1 and .88 for C_2, for hyperactivity was .86 for C_1 and .84 for C_2, and for impulsivity was .81 for C_1 and 80 for C_2, respectively.

Social competence

Social competence was assessed using the subscale "Close Friendships" of a Dutch version of the Harters' Self Perception Profile of Adolescents (Harter, 1988; Treffers et al., 2002). The subscale included five items (e.g., "I find it hard to get friends on whom I can count"), which response options ranged on a 5-point scale from 1 = *Totally disagree* to 5 = *Totally agree*. Mean scores on the five items were calculated and used as a measure of social competence. Higher scores indicated more problems with establishing and retaining close friendships and thus poorer social competence. Cronbach's α was .66 for C_1 and .62 for C_2.

Gaming behavior

Several questions regarding gaming behavior were assessed. Participants were first asked whether they had played any game in the past 3 months (0 = *No*, 1 = *Yes*). Those who indicated *Yes* received follow-up questions about the number of days per week that they played games (0 = less than once a week, 8 = seven days per week), and about the hours spend on gaming during a particular gaming day (0 = *less than 1 hour*, 9 = *nine or more hours a day*).

Internet gaming disorder

IGD was assessed with the Internet Gaming Disorder Scale (Lemmens et al., 2015). This scale is based on the nine criteria described in the DSM-5 appendix (Psychiatric Association & American Psychiatric Association, 2013). Respondents who indicated that they recently played games (in the last 3 months) were asked to what extent they experienced problematic gaming symptoms in the past 6 months by answering *Yes* or *No* to nine symptoms. An example symptom is "Have there been periods when you were constantly thinking about a game while at school or work?." A sum score of the nine items was calculated, with a higher score indicating more problems. Cronbach's α was .78 for C_1 and .81 for C_2.

Data-Analytic Strategy

We first created a latent continuous variable called Problematic Gaming by using IGD, gaming frequency, and gaming duration. Thereafter, hierarchical linear regression analyses were performed to examine the roles of reward types (random rewards, social rewards, contingencies rewards, meta-achievements)

and individual vulnerabilities (attentional problem, hyperactivity, impulsivity, low social competence) in the association with problematic gaming. In the second step, interaction terms between reward types and individual vulnerabilities were analyzed. All analyses were performed using Mplus version 8.6. Missing data were handled with full information maximum likelihood estimation (FIML).

Results

Table 1 shows the descriptive statistics for our study variables. Statistically significant gender differences were found. That is, males reported playing video games more often during the week and more hours per session than females. Similarly, boys are more vulnerable to IGD, attentional disorder, impulsivity, hyperactivity, and low social competence. Bivariate correlations revealed no significant associations between age and the total number of hours spent playing video games per session nor the number of gaming sessions per week. Correlations between principal variables are presented in Table 2.

The most frequently played games reported by the participants, and the frequency of the different reward types of the video games played are indicated in Tables 3 and 4. Results showed that the most played games were also those that contained the most rewarding elements, thereby suggesting that the most popular games are those characterized by the investigated reward types.

In line with our assumption, both regression analyses (for C_1 and C_2), controlled for age, gender, and educational level of participants, revealed that adolescents who played games including one (or more) of the following three rewarding features, i.e., random rewards, contingencies rewards, and

Table 1. Descriptive statistics of $Cohort_1$ and $Cohort_2$.

	Boys		Girls			
	M	SD	M	SD	*t*	95% CI
Cohort 1						
Age	14.00	1.21	13.86	1.19	3.22**	[0.05; 0.24]
IGD	2.53	2.78	1.16	2.19	12.14***	[1.14; 1.58]
Gaming frequency	4.66	2.13	2.46	1.90	24.65***	[2.02; 2.37]
Gaming duration	3.64	2.34	2.17	2.11	14.88***	[1.27; 1.66]
Attentional disorder	2.38	.79	2.26	.73	3.92***	[0.05; 0.17]
Impulsivity	2.09	.75	1.84	.68	8.62***	[0.18; 0.29]
Hyperactivity	2.28	.91	2.14	.84	4.09***	[0.07; 0.20]
Low social competence	2.25	.69	2.17	.57	2.96**	[0.02; 0.12]
Cohort 2						
Age	14.76	1.31	14.63	1.25	*1.900	[−0.01; 0.24]
IGD	2.72	2.77	1.38	2.42	8.975***	[1.04; 1.62]
Gaming frequency	4.78	2.14	2.50	2.07	19.178***	[2.03; 2.50]
Gaming duration	3.82	2.41	2.41	2.36	10.471***	[1.14; 1.66]
Attentional disorder	2.43	.81	2.36	.73	1.750*	[−0.01; 0.14]
Impulsivity	2.07	.73	1.90	.66	4.715***	[0.09; 0.23]
Hyperactivity	2.28	.89	2.20	.83	1.937*	[−0.01; 0.16]
Low social competence	2.25	.67	2.22	.59	.858	[−0.03; 0.09]

***$p < .001$; **$p < .01$; *$p < .05$.

Table 2. Correlation between principal variables.

Cohort 1	1	2	3	4	5	6	7
1. IGD	–						
2. Gaming frequency	.466*	–					
3. Gaming duration	.562*	.507*	–				
4. Random rewards	.308*	.294*	.350*	–			
5. Contingencies rewards	.327*	.308*	.281*	.440*	–		
6. Social rewards	.281*	.281*	.312*	.527*	.350*	–	
7. Meta-achievements	.248*	.234*	.271*	.592*	.328*	.622*	–
Cohort 2							
1. IGD	–						
2. Gaming frequency	.470*	–					
3. Gaming duration	.588*	.507*	–				
4. Random rewards	.359*	.391*	.404*	–			
5. Contingencies rewards	.372*	.400*	.360*	.594*	–		
6. Social rewards	.340*	.377*	.377*	.648*	.556*	–	
7. Meta-achievements	.304*	.342*	.318*	.620*	.612*	.627*	–

*Correlation is significant at the 0.01 level (2-tailed).

Table 3. Frequency of the five most reported games in the last 3 months (in percentages) and their reward types.

Cohort 1	Frequency of most played games (%)	Random rewards *presence*	Contingencies rewards *presence*	Social rewards *presence*	Meta-achievements *presence*
Most played games					
FIFA	2.5	✓	✓	✓	✓
Grand Theft Auto	16.0	✓		✓	✓
Call of Duty	9.6	✓	✓	✓	✓
Overwatch	5.6	✓	✓	✓	✓
H1Z1	4.6	✓	✓	✓	✓
Cohort 2					
Most played games					
Fortnite	39.7	✓	✓	✓	✓
FIFA	8.4	✓	✓	✓	✓
Grand Theft Auto	5.1	✓		✓	✓
Call of Duty	4.7	✓	✓	✓	✓
Minecraft	4.7	✓		✓	✓

social rewards, reported more problematic gaming behavior (Table 5). In contrast, the effect of meta-achievements on problematic game use was not statistically significant, neither for C_1 nor C_2.

Differences between the two cohorts have been found regarding individual vulnerabilities. In C_1, attentional disorder, impulsivity, hyperactivity, and low social competence were significantly associated with problematic gaming ($p < .05$), indicating that adolescents who reported higher levels for the above-mentioned individual vulnerabilities, tend to engage in more problematic gaming behavior. However, for C_2 only attentional disorder and impulsivity were statistically significant ($p < .001$) in association with problematic game play.

Lastly, we tested whether individual vulnerabilities moderated the effects of game rewards on problematic gaming behavior. As can be seen in Table 6, in

Table 4. Frequency of the rewards type of all the video games ($n = 186$) reported to be played in the last 3 months (in percentages).

Cohort 1	Frequency of reward in games (%)
Reward types	
Random rewards	71.4
Contingencies rewards	40.5
Social rewards	75.1
Meta-achievements	64.9
Cohort 2	
Reward types	
Random rewards	74.4
Contingencies rewards	54.4
Social rewards	75.3
Meta-achievements	67.4

Table 5. Summary of regression analysis of video reward types and individual vulnerabilities on problematic gaming behavior.

	Cohort 1 ($N = 2041$)			Cohort 2 ($N = 1256$)		
Control Variables	*b*	SE	p	*b*	SE	p
Gender	− 0.217	0.028	.000	− 0.230	0.039	.000
Age	− 0.124	0.020	.000	− 0.205	0.027	.000
Educational level	− 0.178	0.020	.000	− 0.031	0.029	.000
Independent Variables						
Reward types						
Random rewards	0.158	0.026	.000	0.221	0.033	.000
Contingencies rewards	0.219	0.023	.000	0.206	0.034	.000
Social rewards	0.107	0.026	.000	0.169	0.034	.000
Meta-achievements	− 0.023	0.029	.421	− 0.049	0.038	.193
Individual vulnerabilities						
Attentional disorder	0.145	0.029	.000	0.130	0.038	.000
Impulsivity	0.186	0.032	.000	0.142	0.038	.000
Hyperactivity	0.062	0.029	.036	0.068	0.036	.058
Low social competence	0.058	0.022	.008	0.049	0.027	.066

Cohort1 $R2 = 0.514$ ($p < .001$); Cohort2 $R2 = 0.535$ ($p < .001$).

both cohorts, attentional disorder significantly moderated the effect of contingencies rewards on problematic gaming (C_1: $b = 0.55$, $p < .001$; C_2: $b = 0.20$, $p < .001$) (Figures S1-S2), indicating that particularly in players with attentional problems, contingencies reward elements were associated with problematic gaming. Additionally, attentional disorder moderated the effect of meta-achievements on problematic gaming, but only for C_1 ($b = 0.22$, $p < .05$) (Figure S3). Regarding the remaining rewards elements (random rewards, social rewards), no moderating effect was found significant for attentional disorders, neither for C_1 nor C_2.

Similar results have been found for impulsivity that positively moderated the effect of contingencies rewards on problematic gaming for both cohorts (C_1: $b = 0.61$, $p < .001$; C_2: $b = 0.39$, $p < .001$) (Figures S6-S7), indicating that contingencies rewards were associated with problematic gaming behavior, particularly in gamers who report a high level of impulsivity (Figures S6-S7). Moreover, results have shown that impulsivity was a significant moderator for

Table 6. Test of individual vulnerabilities as moderators between reward types and problematic gaming behavior.

	Cohort 1 ($N = 2697$)			Cohort 2 ($N = 1608$)		
Attentional Disorder	*b*	SE	p	*b*	SE	p
RRew × Att	0.059	0.095	.536	− 0.149	0.132	.257
CRew × Att	**0.558**	**0.085**	**.000**	**0.205**	**0.111**	**.000**
SRew × Att	− 0.026	0.095	.786	− 0.128	0.146	.382
MRew × Att	**0.224**	**0.102**	**.028**	0.148	0.135	.275
Hyperactivity	Cohort 1 ($N = 2689$)			Cohort 2 ($N = 1605$)		
RRew × Hyp	0.040	0.092	.661	− 0.101	0.129	.435
CRew × Hyp	**0.391**	**0.077**	**.000**	**0.250**	**0.111**	**.000**
SRew × Hyp	0.190	0.099	.055	0.067	0.139	.629
MRew × Hyp	0.066	0.100	.509	− 0.047	0.123	.702
Impulsivity	Cohort 1 ($N = 2695$)			Cohort 2 ($N = 1606$)		
RRew × Imp	− 0.156	0.101	.121	− 0.141	0.145	.333
CRew × Imp	**0.615**	**0.077**	**.000**	**0.396**	**0.111**	**.000**
SRew × Imp	0.150	0.108	.162	0.085	0.161	.598
MRew × Imp	**0.236**	**0.102**	**.021**	− 0.024	0.141	.867
Low social competence	Cohort 1 ($N = 2655$)			Cohort 2 ($N = 1597$)		
RRew × Soc	0.019	0.115	.867	− 0.147	0.149	.327
CRew × Soc	0.121	0.098	.217	0.159	0.132	.227
SRew × Soc	**0.325**	**0.111**	**.003**	**0.118**	**0.157**	**.001**
MRew × Soc	− 0.093	0.123	.448	0.007	0.159	.963

Cohort$_1$ $R^2 = 0.471$ ($p < .001$); Cohort$_2$ $R^2 = 0.477$ ($p < .001$).
Cohort$_1$ $R^2 = 0.426$ ($p < .001$); Cohort$_2$ $R^2 = 0.453$ ($p < .001$).
Cohort$_1$ $R^2 = 0.475$ ($p < .001$); Cohort$_2$ $R^2 = 0.475$ ($p < .001$).
Cohort$_1$ $R^2 = 0.357$ ($p < .001$); Cohort$_2$ $R^2 = 0.405$ ($p < .001$).

the effect of meta-achievements on problematic gaming, but only for C_1 ($b = 0.23$, $p < .05$) (Figure S8). Impulsivity did not moderate other effects of reward elements (random rewards, social rewards) on problematic game play.

Hyperactivity has been found to positively moderate the effect of contingencies rewards on problematic game play in both cohorts (C_1: $b = 0.39$, $p < .001$; C_2: $b = 0.25$, $p < .001$) (Figures S4-S5), suggesting that contingencies reward features had a stronger impact on problematic gaming more for hyperactive gamers rather than non-hyperactive ones. None of the remaining effects of reward elements (random rewards, social rewards, meta-achievement) on problematic game use were found to be moderated by hyperactivity, neither for C_1 nor C_2.

Finally, results showed that social competence was a significant moderator of the effect of social reward on problematic gaming for both cohorts (C_1: $b = 0.32$, $p < .05$; C_2: $b = 0.11$, $p < .05$) (Figures S9-S10). Gamers who perceive a low social competence, report more problematic gaming behaviors resulting from social rewards, in comparison to gamers with a high perceived social competence. Regarding the other rewards elements (random rewards, contingencies rewards, meta-achievements), no moderating effects were found for social competence.

Discussion

There is an ongoing societal debate about the rewarding elements in games and how these elements may contribute to problematic game play, particularly among younger players. To the best of our knowledge, this is the first study that investigated the relationship between specific rewarding elements in video games and problematic gaming behavior in young adolescents. Our findings suggest that certain rewarding elements (i.e., random reward system, contingencies rewards, and social rewards) are associated with more problematic game play. Adolescents who play games including such rewards reported more problematic gaming behavior. Moreover, playing these specific videogames may be particularly risky for certain groups of adolescents, particularly those who experience higher levels of ADHD symptoms and/or social problems.

A possible explanation for why certain reward types in games are associated with problematic gaming behavior is that such reinforcing features may promote a state of flow, which occurs when a player experiences intense enjoyment from being immersed in the game, resulting in a distorted sense of time (Kim & Davis, 2009; Kuss & Griffiths, 2012a). This may particularly be true for contingencies rewards and specifically for adolescents who report symptoms of ADHD. The state of flow can be easier to achieve in games with contingencies rewards since players are rewarded for their continuity in game sessions. Possibly the experience of flow may have a stronger impact on adolescent gamers with ADHD symptoms, as these gamers generally tend to experience more attention problems during tasks that demand sustained attention. For this group of gamers, the experience of being able to pay attention to a specific task for a longer time and experiencing flow or hyperfocus may be more rewarding in itself (Peeters et al., 2019). Also, players with ADHD symptomatology generally have more problems with delaying rewards and organizing their daily activities (Barkley, 1997; Engle, 2002). As a result, they may be more preoccupied with and influenced by these rewards than players without these symptoms.

The present study, furthermore, indicates that structural characteristics that promote feelings of connectedness, such as social rewards, are also perceived as reinforcing for gamers, particularly young gamers who indicate having difficulties with social interaction. It seems that adolescents who experience issues with real-life social interactions may particularly be drawn to games with social features. These social features can help adolescents to receive and improve their social status in games, and/or to increase feelings of acceptance and belonging through social interaction with peers (Beranuy et al., 2013; Forrest et al., 2016). Therefore, games with these socially rewarding elements may particularly attract adolescents with social difficulties and can accelerate the process of recreational to problematic game play.

The results can also be understood on basis of the DSMM model (Valkenburg & Peter, 2013) perspective according to which individual

vulnerabilities not only moderate the effect of the media feature (i.e., games' reward type) on gaming behavior but they can also predispose the media use (i.e., game selection). Individuals have the tendency to seek out media that, at least to a certain extent, converge with their dispositions (Fikkers & Piotrowski, 2020), developmental level (Valkenburg & Cantor, 2000), and the norms that prevail in the social groups to which they belong (McDonald, 2009). It is therefore possible that players characterized by ADHD symptomatology and low social skills choose to play games that contain those reward mechanisms able to fulfill their specific needs.

Finally, regarding the absence of significant findings related to meta-achievements, this can possibly be explained by the fact that such rewards are placed on a secondary saliency level compared to more immediate rewards for players such as random and contingencies rewards. However, our findings also suggest that meta-achievements may be more relevant to players characterized by attentional disorder and impulsivity. It is possible that obtaining meta-achievements rewards may be particularly rewarding for players with attentional disorder because the process prior to earning these rewards requires sustained attention and hyperfocus. Moreover, previous studies have shown that impulsivity may be related to some aspects of completism and collecting (Possler et al., 2017; Starcevic & Aboujaoude, 2017), elements that are salient for meta-achievements given the game system for obtaining such rewards. Since these findings are not replicated in both cohorts, this may mean that the role of meta-achievement rewards for these players may also be determined by other game elements that are not always present in every videogames.

Limitations and Future Research

The results of this study should be interpreted considering some limitations. First, due to the nature of cross-sectional data, it is not possible to draw conclusions regarding causality. However, the aim of this study was to investigate how game elements relate to concurrent players' behavior, given the fact that the popularity of different games varies over time. A longitudinal design would therefore not be suitable to answer this question. Second, the participants' self-reported gaming behavior may have resulted in at least partly flawed answers due to social desirability bias and/or a lack of introspection. Third, in the present study, we did not assess the motivations that drive players in gaming. The primary motivation for playing video games may differ among players (e.g., intrinsic, extrinsic) and may thus influence their gaming behaviors differently (Blinka & Mikuška, 2014; Zhong & Yao, 2013). Fourth, it is possible that the impact of reward types may be more pronounced in some games or game genres than in others. For example, the gameplay of games such as FIFA or Fortnite is strongly based on random rewards, while Call of Duty or Overwatch gameplays tend to focus more on contingencies reward

mechanisms. Therefore, future research may use different study designs to unravel the exact impact of rewards on gaming behavior. For instance, observational research could explore the nature and experience of structural characteristics while gamers are actually playing in their normal gaming context, rather than via retrospective self-report surveys or playing games for unnatural restricted periods in laboratory settings. One way forward in the field would be for gaming operators to provide access to real-time behavioral tracking data of players so that researchers can conduct secondary analyses of gaming behaviors in relation to specific in-game structural characteristics and rewards.

Conclusion

As video games become increasingly complex and interwoven with modern life, it is important that researchers can recognize and understand the psychological effects that these new technologies can bring to the lives of young gamers, both for better and for worse. The current research adds to previous knowledge about risk factors of problematic gaming by identifying the potential negative impact of certain rewarding features in games for the development of problematic gaming and by recognizing groups of adolescents that are particularly vulnerable to these rewarding features. The study findings suggest a few implications for the prevention and intervention of problematic gaming behavior. First, gaming companies could introduce features in a game to assist those who may be prone to addictive tendencies from losing track of time while playing; features could be built into a game to remind players to take regular breaks by having subtle "pop-up" messages to inform players of time spent gaming in a single session. Furthermore, more transparent fixed probabilities to get an item would allow the players to know how long they may need to play before getting an item, thus preventing some from engaging in a long activity. Lastly, indicated prevention and clinical treatment of problematic gaming behavior could include providing tailored information regarding the most worrisome games for these particular youngsters, as well as promoting alternative behaviors that may be perceived as equally rewarding. Knowledge about which aspects of games are most rewarding or most irresistible for certain individuals may help to prevent and/or diminish maladaptive gaming patterns, while, at the same time, optimizing the benefits of healthy gameplay, for instance by promoting social connection, social status, and pleasure (Griffiths & Pontes, 2020; Griffiths, Kuss, & Pontes, 2016).

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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