FULL-LENGTH REPORT

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Established risk factors for addiction fail to discriminate between healthy gamers and gamers endorsing DSM-5 Internet gaming disorder

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Background and aims: The DSM-5 includes criteria for diagnosing Internet gaming disorder (IGD) that are adapted from substance abuse and widely used in research and clinical contexts, although evidence supporting their validity remains scarce. This study compared online gamers who do or do not endorse IGD criteria regarding self-control-related abilities (impulsivity, inhibitory control, and decision-making), considered the hallmarks of addictive behaviors. *Method:* A double approach was adopted to distinguish pathological from recreational gamers: The first is the classic DSM-5 approach (≥5 criteria required to endorse the IGD diagnosis), and the second consists in using latent class analysis (LCA) for IGD criteria to distinguish gamers' subgroups. We computed comparisons separately for each approach. Ninety-seven volunteer gamers from the community were recruited. Self-reported questionnaires were used to measure demographic- and game-related characteristics, problematic online gaming (with the Problematic Online Gaming Questionnaire), impulsivity (with the UPPS-P Impulsive Behavior Scale), and depression (with the Beck Depression Inventory-II). Experimental tasks were used to measure inhibitory control (Hybrid-Stop Task) and decision-making abilities (Game of Dice Task). *Results:* Thirty-two participants met IGD criteria (33% of the sample), whereas LCA identified two groups of gamers [pathological (35%) and recreational]. Comparisons that used both approaches (DSM-5 and LCA) failed to identify significant differences regarding all constructs except for variables related to actual or problematic gaming behaviors. *Discussion:* The validity of IGD criteria is questioned, mostly with respect to their relevance in distinguishing high engagement from pathological involvement in video games.

Keywords: Internet gaming disorder, inhibitory control, impulsivity, decision-making, DSM-5

INTRODUCTION

The study of video game-related disorders took a step forward with the inclusion of Internet gaming disorder (IGD), as proposed in Section 3 of the fifth edition of the *Diagnostic and Statistical Manual for Mental Disorders* (DSM-5; American Psychiatric Association [APA], 2013; Petry & O'Brien, 2013; Table 1), encouraging further research on this condition. Directly transposed from established substance abuse diagnostic criteria and including dimensions such as tolerance or withdrawal, the proposed IGD criteria have already generated much debate and controversy (Griffiths et al., 2016; Kardefelt-Winther, 2015; Petry et al., 2016). Although evidence regarding their validity is still limited (e.g., Király, Sleczka, et al., 2017; Ko et al., 2014), some studies have nevertheless used these criteria to determine the prevalence of IGD in population-based samples, mainly young adults, reporting rates of between 0.3% and 1.3% (e.g., Przybylski, Weinstein, & Murayama, 2017; Rehbein, Kliem, Baier, Mößle, & Petry, 2015). As caution is required before using a newly established diagnostic criteria in population-based epidemiological studies (van Rooij & Kardefelt-Winther, 2017; van Rooij, Van Looy, & Billieux, 2017), we aimed in the current report to test whether established risk factors for addictive behaviors successfully discriminate gamers who endorse DSM-5 IGD criteria from healthy gamers, and thus to gather new evidence regarding

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Table 1. Internet gaming disorder criteria and percentages of gamers per criteria

IGD criteria (DSM-5)	Percentage of “yes” ($N = 97$)
Preoccupation with Internet games	77.3
Withdrawal symptoms when games are taken away	14.4
Tolerance (need for increasing the amount of time spent playing)	35.1
Unsuccessful attempts to control participation in games	48.5
Loss of interest in other activities	21.6
Continued use despite problem awareness	59.8
Deceiving relatives	30.9
Use for mood regulation	39.2
Jeopardize relationship or job	15.5
Proportion of participants endorsing IGD criteria (5+ criteria)	33

Note. IGD: Internet gaming disorder.

the construct validity of IGD criteria. In this study, we focused on three constructs that are widely identified as being crucial in gaming disorder and constituting hallmarks of addictive disorders: inhibitory control, decision-making, and impulsivity traits (Bechara, 2005; Goldstein & Volkow, 2011; Volkow, Wang, Fowler, & Tomasi, 2012).

In the last two decades, a growing corpus of data has emphasized the role of inhibitory and decision-making deficits, along with heightened impulsivity traits, in the etiology of excessive video game use (Gentile et al., 2011; Littel et al., 2012; Pawlikowski & Brand, 2011; Yao et al., 2015), in line with what had long been identified in substance-related addictive states (Biernacki, McLennan, Terrett, Labuschagne, & Rendell, 2016; Coskunpinar, Dir, & Cyders, 2013; Smith, Mattick, Jamadar, & Iredale, 2014). These self-control-related constructs are incorporated in the most recent models of IGD (Brand, Young, Laier, Wölfling, & Potenza, 2016) and constitute important factors in the influential “dual-process” models of addictive disorders (Bechara, 2005; D’Hondt, Billieux, & Maurage, 2015).

Since the release of the DSM-5, a growing number of studies have explored impulsivity traits and impairments in executive function in individuals with IGD, producing mixed findings (e.g., Argyriou, Davison, & Lee, 2017; Brand et al., 2016). Some studies have, e.g., shown that individuals with IGD are characterized by reduced response inhibition and mental flexibility (Choi et al., 2014; Yao et al., 2015; Zhou, Yuan, & Yao, 2012), whereas another study failed to identify inhibitory control impairment in IGD with a Go/No-Go (GNG) task (Ding et al., 2014). Other studies have shown IGD to be related to proneness to make disadvantageous decisions in various laboratory tasks, supposedly because of more impulsive reward seeking (Wang, Wu, Lin, et al., 2016; Wang, Wu, Wang, et al., 2016). Furthermore, on the basis of both self-reported and neuroimaging measures, IGD also appears to rely on heightened impulsivity (Choi et al., 2014; Ding et al., 2014; Ko et al., 2015; Yen et al., 2017).

Following the ongoing debates on IGD conceptualization and diagnosis (Griffiths et al., 2016; Kuss, Griffiths, & Pontes, 2016), we intended this study to fill an important gap by comparing gamers who endorse the tentative criteria for IGD in the DSM-5 with gamers who do not for the aforementioned self-control-related constructs, namely inhibitory control, decision-making abilities, and impulsivity traits. Indeed, if the DSM-5 criteria successfully allowed diagnosis of IGD as an addictive behavior, then established risk factors for addiction such as those mentioned above should differ between groups, as has been shown in gambling disorder (Billieux, Lagrange, et al., 2012; Brevers, Bechara, Cleeremans, & Noël, 2013; Devos, Clark, Maurage, Kazimierczuk, & Billieux, 2015; van Holst, van den Brink, Veltman, & Goudriaan, 2010). A double approach was adopted because of the still preliminary nature of IGD criteria. First, the polythetic approach proposed in the DSM-5 was used, i.e., considering gamers who endorse five or more criteria to be presenting IGD. Second, a data-driven approach that consisted of applying latent class analysis (LCA) to the same diagnostic criteria was conducted to potentially identify a group of problematic gamers. Construct validity of IGD criteria was addressed through the use of a problematic gaming questionnaire, and depressive symptoms were controlled for as potential confounding variables (Bargeron & Hormes, 2017; Gentile et al., 2011).

METHODS

Participants

Ninety-seven gamers (87% males) were recruited through Facebook, word of mouth, and announcements in the Université catholique de Louvain (Louvain-la-Neuve, Belgium). Inclusion criteria were being above 18 years of age, a fluent French speaker, and playing online video games weekly. The age of the participants ranged from 18 to 39 years ($M = 22.21$, $SD = 3.73$). Regarding education, 71% had a secondary school diploma, 25% a university diploma, and 4% a non-university higher education degree.

Measures

IGD criteria. IGD was assessed using the questionnaire elaborated by Petry et al. (2014). In their article, they proposed the questionnaire in several other languages, including French. Gamers answer “yes” or “no” to at least five of the nine criteria occurring over the past 12 months in order to endorse IGD. The nine dichotomous items measure IGD criteria: preoccupation, withdrawal, tolerance, unsuccessful attempts to stop or reduce the time spent playing, loss of interest in other hobbies or activities, excessive gaming despite problems, deception, escape or relief from a negative mood, and jeopardizing a relationship or job.

Problematic Online Gaming Questionnaire (POGQ). The POGQ was developed by Demetrovics et al. (2012) to measure six facets of problematic online gaming. It is composed of 18 items measuring preoccupation (i.e., obsessive thinking about the game or daydreaming; Cronbach’s $\alpha = .75$), overuse (i.e., not controlling the time spent playing; Cronbach's α = .79), immersion (i.e., losing track of time when playing; Cronbach's α = .67), interpersonal conflicts (i.e., conflicts with relatives due to video games; Cronbach's α = .70), social isolation (i.e., neglecting "real" social interactions for the benefits of online gaming; Cronbach's α = .60), and withdrawal (i.e., being irritated when not being able to play; Cronbach's α = .74). For this study, a total score was calculated (Cronbach's α = .84), the minimum score being 18 and the maximum 90. A French translation has been conducted with a translation–back translation method.

Short UPPS Impulsive Behavior Scale (s-UPPS-P). The s-UPPS-P (Billieux, Rochat, et al., 2012) is a 20-item questionnaire assessing the different impulsivity components. Each item is scored on a 4-point Likert Scale. Five impulsivity facets are measured: negative and positive urgency (i.e., acting under the influence of emotions; with Cronbach's αs of .82 and .76, respectively), lack of premeditation (i.e., difficulties considering the consequences of an action; Cronbach's α = .87), lack of perseverance (i.e., difficulties remaining focused on a difficult or boring task; Cronbach's α = .92), and sensation seeking (i.e., searching for new and thrilling experiences; Cronbach's α = .82). On the basis of recent research (Berg, Latzman, Bliwise, & Lilienfeld, 2015), positive and negative urgency facets were merged into an "urgency" construct (i.e., the tendency to act rashly in intense emotional contexts) because of their high correlation ($r = .56$, $p < .001$).

Beck Depression Inventory-II (BDI-II). The French version of the BDI-II (Beck, Steer, & Brown, 1998) was used to measure depressive symptoms. With 21 items on a 4-point Likert scale, depression scores may vary between 0 and 63, with 0–13 for absence of depression, 14–19 for light depression, 20–28 for moderate depression, and 28 or more for severe depression. The global internal consistency is high (Cronbach's α = .79).

The Hybrid-Stop Task (HST). The HST was developed by Schachar, Forget-Dubois, Dionne, Boivin, and Robaey (2011) and designed with E-Prime 2.0.8. The originality of this task is that it measures two different inhibition processes: cancellation (i.e., the capacity to interrupt an ongoing automatic action) and restraint of a prepotent motor response (i.e., the capacity to prevent an action from occurring when required).

Three different trials are measured: Go trials (for the reaction time), No-Go trials (for the restraint process), and stop-signal trials (SST) (for the cancellation process). During the training block composed of 16 trials, the intention is to automatize the association between the stimuli that appear and the response keys. Following this step, the task begins with a total of 320 trials divided into five blocks. The 160 Go trials require the participant to answer as quickly as possible by pressing on the keyboard to indicate in which direction a black arrow appearing in the middle of the screen is pointing (left or right). In GNG trials (80 trials), the blue arrow appears immediately, requiring the participant to restrain his/her answer. In SST (80 trials), the arrow turns blue after a short delay, requiring the participant to cancel the ongoing prepotent response. The first stop-signal delay is based on the mean reaction time measured during the training session, after which a dynamic algorithm modifies the duration of the delay: 50 ms slower if the participant did not succeed in inhibiting the answer (making the next SST easier to inhibit), and 50 ms faster after successful inhibition (making the next SST harder to inhibit).

Crucially, the instruction given to the participant stresses giving an answer as quickly as possible, without anticipating the possible occurrence of the SST. The average time required to successfully inhibit a motor answer is calculated with the stop-signal reaction time (Logan, 1994) estimated via the integration method (Logan & Cowan, 1984). For GNG, the percentage of errors (i.e., when responding to blue arrows) was calculated. For each participant, all errors made in Go trials were removed prior to the calculation of mean reaction time. Late responses were suppressed by removing every reaction time in Go trials that was longer than the mean for Go trials plus 2.5 standard deviations on a subject-by-subject basis.

The Game of Dice Task (GDT). Decision-making abilities were measured with the GDT (Brand et al., 2005) in which participants have to maximize their virtual money capital in risky situations, i.e., where the individual is aware of the task contingencies. A short clip on the left of the screen shows dice being shaken in a cup. On the center and top right, the participant sees his/her current capital and the feedback boxes where losses and gains are displayed in both figures and columns. In the center of the screen, different clickable bets show the amounts of winnable money, which vary depending on the probability of winning. The throws are pseudorandomized in order for all six values to be displayed three times.

Choices in the GDT are either advantageous or disadvantageous. Choices with one or two values are considered disadvantageous, with elevated probabilities of winning or losing high amounts of money more frequently, whereas choices with three or four values are advantageous, with probabilities of winning or losing smaller amounts being over 50%.

Following the guidelines provided by the task's creators (Brand et al., 2005), a net score consisting in the subtraction of disadvantageous choices from advantageous choices is calculated as an indicator of overall task performance. Higher net scores are indicators of advantageous decision strategies.

Procedure

Participants were first selected through an online survey (Qualtrics, Provo, UT) to ensure that they met the inclusion criteria. They were then individually contacted by e-mail to arrange an appointment to complete the experiment in a quiet laboratory. They signed an informed consent form prior to starting the experiment and were debriefed regarding the objectives at the end. The study started with a questionnaire that assessed demographic variables (age, gender, educational level, and current job or study) and game-related factors (gaming frequency and preferences). Participants then participated in two laboratory tasks that assessed inhibitory control with the HST (Schachar et al., 2011) and decision-making with the GDT (Brand et al., 2005). They also completed questionnaires that assessed DSM-5 IGD criteria (Petry et al., 2014), impulsivity traits with the s-UPPS-P (Billieux, Rochat, et al., 2012), symptoms of problematic video game use with the POGQ

(Demetrovics et al., 2012), and symptoms of depression with the BDI-II (Beck et al., 1998). Participants received an incentive of 10 euros for their participation. Some results from the current data set, unrelated to the objective of this study, have been published elsewhere (Deleuze, Christiaens, Nuyens, & Billieux, 2017).

Statistical analysis

T-tests were used to compare participants endorsing or not DSM-5 IGD criteria on study variables. LCAs were performed using R software (R Development Core Team, 2008) with the poLCA package (Linzer & Lewis, 2011). LCA is a multivariate method that identifies discrete multivariate variables called latent classes on the basis of multivariate categorical data. Its advantage over other analyses such as cluster analysis is that it allows the use of binary variables. In this study, LCA was performed on each criterion's endorsement (1 = endorsement and 0 = non-endorsement) to, first, identify different profiles of online gamers and, second, to determine the probabilities for members from each class to endorse all IGD criteria. The maximum posterior probability served as the assignment of each participant in classes.

Different models ranging from 1 to 10 classes were tested in an exploratory way. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were both calculated, penalizing the number of estimated parameters for parsimoniousness and the quality of the model. An additional index of entropy was calculated for the model accuracy, with values close to 1 meaning better homogeneity of the classes. The final decision for the model retained depends on these indices and on closeness to reality. Table 2 shows the AIC and BIC indices of fitting and the entropy measure for the 10 tested models. The BIC and AIC indicated a two-class model. For entropy, caution must be taken, as it progressively increased, whereas the opposite is sought, given the higher risks of assignment errors (Collins & Lanza, 2013). An increase in the entropy score between the two- and three-class solutions speaks in favor of a three-class model. The final choice for the two-class model was motivated by the principle of parsimony and based on the need for IGD criteria to distinguish problematic gamers from regular gamers.

Table 2. Fit indices for latent class analyses

Number of latent classes	AIC	BIC	Entropy
1	1,027.49	1,050.66	1
2	1,001.72	1,050.65	0.69
3	1,006.16	1,080.83	0.82
4	1,006.30	1,106.71	0.77
5	1,013.09	1,139.26	0.91
6	1,016.08	1,167.99	0.93
7	1,030.17	1,207.82	0.92
8	1,037.24	1,240.64	0.89
9	1,050.50	1,279.65	0.91
10	1,055.43	1,310.32	0.94

Note. AIC: Akaike information criterion; BIC: Bayesian information criterion.

Ethics

The ethical committee of the Psychological Science Research Institute of the Université catholique de Louvain (Belgium) approved the study protocol. All subjects were informed about the anonymity of the study and provided their informed consent.

RESULTS

Endorsement of DSM-5 IGD criteria and group comparisons

Table 1 shows endorsement proportions for each IGD criterion. Of the 97 gamers involved in the study, 32 endorsed five or more IGD criteria. Consequently, we compared individuals who endorsed five or more criteria with those who endorsed fewer than five criteria.

Table 3 shows a series of *t*-tests conducted between participants identified as endorsing or not endorsing IGD regarding the study variables. No significant difference appeared between groups for demographics, impulsivity traits (s-UPPS-P), inhibitory control (HST), decision-making abilities (GDT), and depressive symptoms (BDI-II). The only differences were that gamers endorsing IGD criteria reported higher POGQ scores and more hours spent playing per week.

LCA and comparisons between classes

An LCA was computed to identify latent subgroups, with a two-class model emerging. Class 1 is composed of 63 gamers (65% of the sample). All endorsement probabilities were below 50% except for *preoccupation* at 65.1%. Class 2 is composed of 34 gamers (35%) who had a higher probability of reporting *loss of control* and *overuse*, all of whom endorsed the *preoccupation* criterion. This second class comprises all participants who endorsed the IGD condition (five criteria or more). Table 3 reports comparisons between healthy and pathological gamers based on the DSM-5 and the LCA approaches.

DISCUSSION

This study used a double approach to explore the validity of IGD criteria proposed in the DSM-5 among gamers from the community. First, individuals who endorsed five or more IGD criteria were compared with recreational gamers (i.e., those who endorsed four or fewer criteria). Second, an LCA was computed from the criteria endorsement, which identified two distinct classes. In both cases, the identified groups were compared for self-control-related constructs (impulsivity traits, inhibitory control, and decision-making), which are considered hallmarks of addictive behaviors. Contrary to our expectations, the results largely failed to highlight expected group differences, as gamers who endorsed criteria defining pathological online video game use and recreational gamers did not present significantly different performances.

The most striking finding of this study is that established risk factors for addictive behaviors failed to distinguish

Table 3. Multiple comparisons between gamers endorsing IGD criteria and control gamers and between LCA classes 1 and 2

		DSM-5 approach		LCA approach		*t*		Cohen's *d*	
		IGD ($n = 32$)	Control ($n = 65$)	Class 1 ($n = 63$)	Class 2 ($n = 34$)	DSM	LCA	DSM	LCA
Demographic measures	Age	21.84 (3.21)	22.38 (3.97)	22.48 (3.99)	21.71 (3.17)	0.669	0.970	0.015	0.021
	Hours/week	19.15 (9.61)	13.90 (8.90)	13.78 (9.01)	19.06 (9.34)	−2.663*	−2.715*	0.56	0.57
Self-reported questionnaires	POGQ – total	50.78 (7.77)	40.98 (7.47)	40.92 (7.53)	50.32 (7.86)	−5.990**	−5.779**	1.28	1.22
	s-UPPS-P – urgency	21.12 (4.18)	19.24 (4.63)	19.27 (4.60)	20.97 (4.32)	−1.936	−1.773	0.42	0.38
	s-UPPS-P – lack of premeditation	7.38 (2.64)	7.28 (2.25)	7.32 (2.27)	7.29 (2.58)	−0.190	0.046	0.04	0.01
	s-UPPS-P – lack of perseverance	7.88 (3.05)	7.46 (2.70)	7.43 (2.74)	7.91 (2.97)	−0.678	−0.805	0.14	0.16
	s-UPPS-P – sensation seeking	11.84 (2.69)	11.08 (2.65)	11 (2.62)	11.94 (2.70)	−1.332	−1.668	0.28	0.35
	BDI-II	9.41 (3.76)	7.46 (5.98)	7.59 (6.03)	9.06 (3.91)	−1.951[b]	−1.282	0.39	0.28
Hybrid-Stop Task	Go RT[a]	480.08 (212.90)	485.56 (221.11)	487.88 (224.25)	476.10 (206.98)	−0.116	0.253	0.02	0.05
	SSRT[a]	266.31 (65.41)	255.42 (51.59)	256.05 (52.14)	264.51 (64.05)	0.893	−0.703	0.18	0.14
	GNG errors, % (restraint process)	3.87 (7.97)	2.19 (2.92)	2.24 (2.95)	3.67 (7.77)	1.150[b]	−1.305[b]	0.28	0.24
	SST errors, % (cancellation process)	63.79 (17.06)	60.96 (15.02)	61.23 (15.18)	63.12 (16.76)	0.833	−0.565	0.17	0.12
Game of Dice Task	Net score	8.62 (9.62)	10.33 (9.27)	10.22 (9.36)	8.94 (9.46)	0.953	0.640	0.18	0.13

Note. IGD: Internet gaming disorder; LCA: latent class analysis; POGQ: Problematic Online Gaming Questionnaire; s-UPPS-P: short UPPS-P Impulsive Behavior Scale; BDI-II: Beck Depression Inventory-II; Go RT: mean reaction time to go trials; SSRT: stop-signal reaction time; GNG errors: percentage of errors in Go/No-Go trials; SST errors: percentage of errors in stop-signal trials; net score: number of disadvantageous choices subtracted from number of advantageous choices.
[a]Go RT and SSRT are expressed in milliseconds. [b]Correction for variance inequality was applied.
*$p < .05$. **$p < .005$.

between gamers presenting or not presenting pathological use of video games as defined by DSM-5 IGD criteria. Indeed, as reported in Table 3, the only differences shown were related to (i) self-reported time spent playing and (ii) symptoms of disordered gaming (assessed with a self-reported continuous scale of disordered use of video games). This finding does not support the validity of the DSM-5 criteria, which were developed from the conceptualization of IGD as an addictive disorder. Indeed, the self-control-related constructs measured in this study have repeatedly been found to be impaired in individuals who present behavioral or substance-related addictive disorders (Biernacki et al., 2016; Coskunpinar et al., 2013; Smith et al., 2014) and are markers of gambling disorder (Billieux, Lagrange, et al., 2012; Brevers et al., 2013; Devos et al., 2015; van Holst et al., 2010), which is to date the only behavioral disorder considered to be a genuine addictive state (APA, 2013). Our results thus question the relevance of recycling substance abuse criteria to those for IGD and more largely the trend that consists in applying these criteria to a wide range of daily life behaviors and/or leisure activities (Aarseth et al., 2017; Billieux, Schimmenti, Khazaal, Maurage, & Heeren, 2015; Kardefelt-Winther et al., 2017). This does not mean that IGD is not a genuine disorder, as it is known that excessive involvement in video games is associated with functional impairment and psychological distress (Billieux et al., 2017); rather, the current DSM-5 proposal to measure IGD is not necessarily valid or pertinent, which is concerning, given its widespread use for epidemiological purposes in recent years. This view is in line with recent claims that symptoms such as *tolerance* or *withdrawal* in relation to IGD are not supported by enough evidence to be retained as diagnostic criteria (King & Delfabbro, 2016; Starcevic, 2016), or that it is misleading to consider *preoccupation* in online video games (or another leisure activity) as an index of pathological behavior (Kardefelt-Winther et al., 2017). As illustrated in Table 1, the *preoccupation* criterion was endorsed by 77.3% of our community sample of regular gamers, further supporting the idea that preoccupation for leisure activities is, in contrast to preoccupation for consumption of a psychoactive substance, not necessarily a sign of deviant or pathological behavior.

One potential explanation for the absence of differences between groups in this study is that DSM-5 IGD criteria are probably not able to distinguish a high but healthy involvement from an excessive and pathological involvement in video games, which could translate into false positives and pathologization of normal behavior. Indeed, Charlton and Danforth (2007) have shown in an influential video game study that classic addiction criteria must be distinguished in relation to their "core" or "peripheral" nature. According to their study, core criteria (i.e., behavioral salience, withdrawal, conflicts, relapse, and reinstatement) are associated with pathological behavior, whereas peripheral criteria (i.e., cognitive salience or preoccupation, tolerance, and euphoria) instead reflect high engagement (or passion) in video games, which is in most cases healthy. Since Charlton and Danforth's seminal study, accumulating data suggest that intense video gaming is not essentially problematic or associated with negative consequences or functional impairment (e.g., Billieux et al., 2013; Király, Tóth, Urbán, Demetrovics,

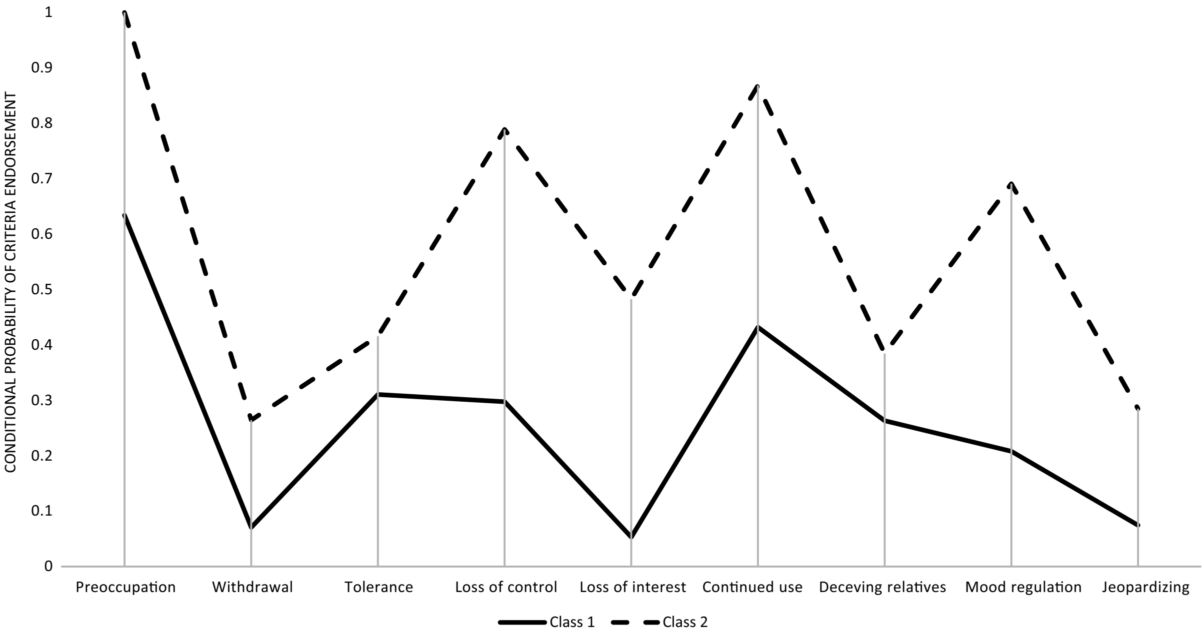

Figure 1. Latent classes based on endorsement of IGD criteria. The number of latent classes is based on the Akaike and Bayesian information criteria

& Maraz, 2017). Accordingly, it is likely that some criteria incorporated in the IGD proposal (e.g., preoccupation and tolerance) constitute peripheral criteria that should not be used to define a pathological condition. In contrast, the LCA allowed us to identify potentially core criteria that could constitute valid predictors of pathological use (Figure 1), such as *loss of control*, continuous involvement despite *negative consequences*, or gaming for *mood regulation*. Relying on two different data-analytic approaches, this study suggests that the polythetic diagnostic approach proposed in the DSM-5 is susceptible to mixing of core and peripheral symptoms, hindering the distinction between highly involved versus pathological cases. This is probably why more than a third of our sample endorsed the pathological threshold.

A specific limitation of the study that is worth mentioning pertains to the study sample. Although the primary objective was to compare pathological versus healthy gamers, it would have been of interest to include a clinical group of treatment-seeking gamers. Indeed, we cannot exclude the possibility that group differences would have emerged if a treatment-seeking group had been included, especially if IGD criteria fail to distinguish between highly involved versus pathological gamers.

In this study, we questioned the validity of the DSM-5 IGD criteria using an original double categorization approach. At a broader level, this study calls for further elaboration and refinement of the diagnostic criteria used to define IGD. In particular, we believe that the establishment of a list of specific IGD diagnostic criteria also requires a focus on the unique psychological and behavioral features associated with this condition (James & Tunney, 2016; Kardefelt-Winther et al., 2017), rather than capitalizing only on similarities to addictive disorders. Moreover, such diagnostic criteria should allow the dissociation of healthy elevated involvement from pathological involvement in order to limit the risk of pathologization of normal behavior. Regarding the latter issue, the recent guidelines provided by the World Health Organization (2017) in a beta draft version of the 11th revision of the International Classification of Diseases appear to be an improvement, as it does not include peripheral criteria and explicitly considers functional impairment as a mandatory criterion for diagnosis (Billieux et al., 2017; Király & Demetrovics, 2017).

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Authors' contribution: JD and JB designed the study. LR and FN created the Hybrid-Stop Task. JD and FN acquired the data. JD and SR ran the statistical analyses. JD and JB interpreted the results. JD and SR also wrote the initial draft of the article. FN, LR, SR, and PM reviewed the initial draft and participated in the writing of the final draft. All authors approved the final version of the manuscript.

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