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ORIGINAL CONTRIBUTION

When addiction symptoms and life problems diverge: a latent class analysis of problematic gaming in a representative multinational sample of European adolescents

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Abstract
The proposed diagnosis of Internet gaming disorder (IGD) in DSM-5 has been criticized for "borrowing" criteria related to substance addiction, as this might result in misclassifying highly involved gamers as having a disorder. In this paper, we took a person-centered statistical approach to group adolescent gamers by levels of addiction-related symptoms and gaming-related problems, compared these groups to traditional scale scores for IGD, and checked how groups were related to psychosocial well-being using a preregistered analysis plan. We performed latent class analysis and regression with items from IGD and psychosocial well-being scales in a representative sample of 7865 adolescent European gamers. Symptoms and problems matched in only two groups: an IGD class (2.2%) having a high level of symptoms and problems and a Normative class (63.5%) having low levels of symptoms and problems. We also identified two classes comprising 30.9% of our sample that would be misclassified based on their report of gaming-related problems: an Engaged class (7.3%) that seemed to correspond to the engaged gamers described in previous literature, and a Concerned class (23.6%) reporting few symptoms but moderate to high levels of problems. Our findings suggest that a reformulation of IGD is needed. Treating Engaged gamers as having IGD when their poor well-being might not be gaming related may delay appropriate treatment, while Concerned gamers may need help to reduce gaming but would not be identified as such. Additional work to describe the phenomenology of these two groups would help refine diagnosis, prevention and treatment for IGD.

Keywords Internet gaming disorder · Video games · Problematic gaming · Hazardous gaming · Adolescence

Introduction

Following years of research and discussion about problematic use of the Internet and video games, Internet Gaming Disorder (IGD) was included in the DSM-5 as a condition for further study, which indicates that the American Psychiatric Association (APA) considers IGD a potential addictive behavior [1]. Researchers then began developing or adapting standardized assessment instruments that could capture the proposed criteria for IGD and reliably identify the disorder in various populations [2–6]. However, in a recent international collaboration of 28 researchers, critical considerations were provided for each criterion with a focus on their theoretical underpinnings, validity and clinical relevance [7]. This group of researchers concluded that the there was still a clear lack of consensus in the field regarding how IGD might best be identified.

While it is fitting for a proposed psychiatric diagnosis to be the subject of debate, it is concerning that survey instruments based on these proposed criteria continue to be developed despite uncertainty about their content, criterion and construct validity [8, 9]. At this point, it is still unclear if all criteria for IGD in DSM-5 actually predict truly problematic behavior in the context of video gaming, or whether they might simply capture high engagement and a healthy interest in gaming [7, 10–12]. This is a key challenge to psychiatry

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for the validity of the IGD construct and the scales and interviews that propose to measure it.

Understanding the relationship between symptoms, problems and psychiatric disorders

For a set of thoughts, feelings and behaviors to be thought of as a disorder in need of treatment, the symptoms of disorder must co-occur with problematic outcomes or clinically significant impairment or distress. The criteria for IGD are based on criteria for substance use disorder [6], and it has been proposed that some of these criteria may only indicate extensive gaming, which is not necessarily associated with problems or pathology [7, 8, 13]. Such criteria when applied to substance use (also a normative behavior when not done to excess) have been called "weak symptoms" [14].

This has significant importance for the utility of instruments used to assess IGD. Because all symptoms are evaluated equally, engaged video gamers (fans of video games who play heavily but do not experience significant problems [10]) may end up being classified as having IGD on the basis of these weak symptoms alone. In this case, IGD criteria may lack specificity, which is especially problematic because gaming is such a popular recreational medium. First, this lack of specificity increases the moral panic associated with video gaming by possibly inflating prevalence figures for IGD [15]. Second, if the population of those who end up being labeled as disordered is actually made up of both problematic and highly engaged video gamers, this could have statistical implications for the study of IGD. If a group of people who are classified as having IGD is actually made up of some who have it and some who do not have it, this will weaken any statistical associations between what we are actually concerned about—truly disordered gaming—and related risk factors, comorbidities and/or harmful outcomes.

To address these problems, we propose a conceptual distinction between symptoms and problems. In this paper we will call the IGD criteria related to symptoms of substance addictions (i.e., impaired control, salience/preoccupation, craving, mood modification, tolerance and withdrawal) *symptom criteria*, and those that translate into more objective indicators of life impairment or interference (i.e., problems with relationships, school/work or other negative consequences) *problem criteria*. Although an actual clinical diagnosis of IGD would require video gaming to be accompanied by at least five symptoms and/or problem criteria along with "clinically significant harm or distress" (a concept similar to the idea of problem criteria), this distinction is not always made in the assessment scales used in population research. Population research occurs by definition in the general population. However, population scales often use polythetic cut-offs (e.g., meeting five out of nine criteria for positive diagnosis or scoring 17 or higher on a 20-point scale), which means that a respondent could theoretically satisfy only symptom criteria and still be diagnosed/labeled as disordered, even though symptom criteria in and of themselves are not indicative of problematic outcomes in community samples [12, 16].

A major challenge for the psychiatry and epidemiology of mental disorders (as opposed to other types of disorder or disease) is that these disorders are represented by signs and symptoms that do not seem to reflect consistent and clear pathological entities and are often widespread in normal populations [17, 18]. While requiring several symptoms to occur at once should theoretically lessen the chance of labeling an individual as having a disorder when they do not, this does not always work. In certain contexts and populations, some criteria may have weak face and predictive validity, which poses a challenge for both clinical assessment and population research.

Using the biaxial model of addiction as a diagnostic gate

Under the biaxial model of addiction, both symptoms and problematic outcomes as a result of the behavior must occur together to define and describe the boundaries of disorder [14]. Survey scales often do not require the presence of problems as a diagnostic "gate", which may lead to individuals who express only the less specific indicators of dysfunction (i.e., weak symptoms [14]) being labeled as disordered or at risk when they are not. While it has been suggested that this may allow for early intervention, a counterargument is that classifying individuals as disordered who actually do not experience problems may waste already strained medical and public health resources [19–21]. A better approach would be to require the biaxial condition to be met in population research: individuals who are to be classified as disordered gamers must experience both symptom criteria and problem criteria [11, 22].

Previous research [7, 23] suggests that for IGD, some criteria reflect relatively normal behaviors that are widespread in the general population of gamers and may not be associated with functional impairment or distress. To illustrate the impact that non-specific or weak symptom criteria can have in the context of video gaming, we might consider the criterion of *preoccupation*. In substance use disorders, this criterion has been used to indicate the cognitive and behavioral faculties devoted to finding and using the substance of choice or the wish to be once again under the influence [1]. In translation to IGD, the core idea is that the person thinks or fantasizes about games, is fascinated with games, and is thinking about the next time they can play [6, 24]. However,

what seems like excessive behavior may be context dependent [13]. Gaming as a pastime differs from substance use in that a lot of time spent thinking about gaming or participating in gaming activities is not necessarily problematic [24–26], nor does it provide physiological input that could directly affect brain functioning beyond what the body can produce by behavior alone [12]. Consider a central concept in playing some types of games, "theorycrafting", which is a careful, focused process that may involve mathematical calculation, community discussions, and creativity which helps optimize the overall gaming experience [27]. A gamer might, for example, think carefully about and discuss with fellow players which piece of armor to create next (e.g., the epic shield or the boots) and the materials they need to craft it (e.g., 150 pieces of iron ore), then calculate how much it will cost to buy all of the materials instead of putting in the time to gather them on their own. This theorycrafting, which by definition involves putting a lot of thought and effort into game play, bears obvious similarities with preoccupation as a criterion for IGD. Therefore, the preoccupation criterion may not be very useful for predicting who may have problems related to gaming because it lacks specificity—it may incorrectly identify as having IGD those gamers who are highly engaged in theorycrafting [28]. Consequently, preoccupation it is at best a weak symptom criterion that lacks specificity and may contribute to misdiagnosis of IGD in certain groups of gamers.

The present research

In this study, we aimed to test whether symptoms and problems related to IGD consistently occur at the same levels (e.g., high levels of symptoms and problems, moderate levels of symptoms and problems, or low levels of symptoms and problems), meaning that the biaxial model of addiction is fulfilled. This is critical because if symptom criteria and problem criteria together are needed to define a disorder, we would expect groups to differ only in the *degree or amount* of symptoms and problems endorsed. If this is the case, then summing scale items or counting symptom criteria related to IGD is appropriate, as these signs and symptoms would constitute a single-dimensional construct that would differ only in degree between people (i.e., severe to absent). However, if we find that people have different levels of endorsement of symptoms and problems (e.g., high symptoms but low problems), this would support our proposition that there are subgroups in the population (e.g. engaged video gamers) for whom symptom endorsement may not correspond to significant life problems, meaning that a sum or polythetically scored IGD survey might lead to misdiagnosis/misclassification. Our approach parallels the need for clinicians to be able to distinguish mental disorders from normal life variation/transient responses to stress and emphasizes the importance of assessment of functional impairment in any attempt to classify a person as having IGD [7, 11].

To be transparent and rigorous in our analysis, we used a publicly available data set and pre-registered our hypotheses and analysis plan, which extended an unpublished initial latent class analysis of these data with several new, untested hypotheses. We also conducted additional exploratory analyses of model assumptions and model validity that were not pre-registered, but are specifically referred to in the text and presented in a Supplementary material Appendix. Our study registration can be found at the Open Science Framework at https://osf.io/um6c7/register/565fb3678c5e4a66b5582f67. By registering hypotheses, we have a transparent way to compare our findings with the results of a traditional variable-based approach (i.e., use of a survey scale that is assumed to measure a single dimension) in this same sample [29].

Methods

Participants

We used secondary data from the EU NET ADB study, a multinational study of Internet and gaming addiction conducted in seven countries in Europe from 2011 to 2012 with 13,708 respondents [30]. Students were sampled using secondary school class as the primary clustering unit in a random probability clustering design. The sampling frame was the official complete list of schools and classes for each country. Each country's ethics committee approved the study protocol and the study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from parents on behalf of their children and verbal assent was obtained from students when questionnaires were completed. Our study sample included those adolescents who were between the ages of 14 and 18 and who played video games at least once a month.

Measures

Internet gaming disorder

Embedded in the EU NET ABD questionnaire is the *Scale for the Assessment of Internet and Computer game Addiction—Gaming Module (AICA-S)* [31], a scale which measures addiction dimensions that are a part of IGD criteria including loss of control, continued use of games despite negative consequences, withdrawal, tolerance, and preoccupation. The scale has good internal consistency (Cronbach's alpha = 0.84 in the current sample) and has good

concordance with clinician ratings of IGD [31, 32]. We used the ten categorical items assessing criteria associated with addictive use of computer games (corresponding to IGD symptom criteria) and six dichotomous items assessing problems associated with computer game play. To assess convergent validity of latent classes, we also created a scale score for the AICA-S based on the recommended scoring of this scale in previous studies [31]. Using this method, a score of 7–13 is considered to be at risk, while a score of 13 or more is considered to be IGD [31].

Categorical items are reported on a 5-point scale ranging from Never to Very Often, except for the two-part item "How often have you tried to give up or limit your online behavior" (*limit*), which is followed by "if you have previously tried to change your online behavior: were you successful?", a yes/no question. We dichotomized the categorical criteria into Never/Seldom/Sometimes and Often/Very Often to ensure that we captured respondents who experienced symptom criteria regularly. We set the cutoff for endorsement at Often/Very Often, which in this case means that those who are said to endorse a symptom will have experienced it at least often, rather than only sometimes or rarely. This ensures that we capture people who, at face value, seem more likely to qualify for a possible clinical disorder. To capture the contingent nature of the two-part *limit* question, we created a trichotomous variable with mutually exclusive and exhaustive categories (i.e., never tried to limit, tried to limit and was successful, tried to limit and was not successful).

Psychosocial well-being

The widely used Youth Self Report (YSR) scale [33] was used to assess mental health, social participation and daily functioning along both positive and negative dimensions. As this dataset had only sum scores for each scale and subscale, we were unable to calculate reliability and consistency measures in this sample; however, previous reports show the scale has excellent psychometric properties [34]. The scale consists of 112 items in the domains of competencies (good/positive well-being) and problems (poor/negative well-being). In addition, competencies are separated into the three subscales of social, academic and activity competencies while problems are separated into the eight subscales of aggressive behavior, anxious-depressed, attention problems, rule-breaking behavior, social problems, somatic problems, thought problems, and withdrawn-depressed. Problem behavior scales are also grouped into internalizing (anxious-depressed, somatic problems, and withdrawn-depressed) and externalizing problems (aggressive behavior, rule-breaking behavior). Items are answered as either absent, occurring sometimes, or occurring often, with the exception of the Academic Performance Scale, which is the mean of self-reported academic performance and ranges from 0 to 3. In keeping with prior research [29], raw scores were used in analysis and were treated as continuous variables.

Internet addiction

The Internet Addiction Test (IAT) [35] was used in an unregistered exploratory analysis to assess the divergent validity of latent classes. This 20-item scale evaluates domains of Internet addiction including preoccupation, compulsive use, and negative consequences. The scale has high reliability with a Cronbach's alpha = 0.92 in the current sample. Responses range from 0 for "never/not applicable" to 5 "always". The total score ranges from 0 to 100, where scores of 40–69 are considered at risk for addictive behavior and scores of 70 or above are considered to represent addictive behavior.

Demographic variables

We also assessed age and sex and used a nominal variable for country. To keep within the scope of our analysis plan and limit the number of hypotheses tested, we did not perform separate analyses for each country, but tested only whether differences between countries existed with this single variable.

Statistical analysis and hypotheses

After first excluding observations likely to be invalid (e.g., straight lining all analysis variables at the highest values), we explored sample distributions and missing data and tested for differences by gender. We performed latent class analysis using the symptom criteria and problem criteria (Table 2) as indicators, accounting for clustering at the class level, and assessed model invariance by gender and regression subsamples in exploratory analyses. Model fit was evaluated using various measures of fit including Bayesian Information Criteria (BIC) and the Lo–Mendell–Rubin (LMR) test as well as qualitative interpretation and parsimony.

In keeping with our preregistered analysis plan, we tested hypotheses related to how our person-centered approach compared to the variable-centered approach taken by a similar study. Our registered hypotheses outline expectations regarding the association between well-being and demographic predictors for latent classes of adolescents that have varying patterns of IGD symptoms and gaming-related problems (Table 1). We expected that any classes defined by having high symptoms but few problems (e.g., an Engaged class) would have overall good well-being, but that classes with high levels of problems (e.g., an IGD class) would have poor well-being. Once classes were established, we evaluated convergent and divergent validity for latent classes in **Hypothesis 1** by testing the

Table 1 Preregistered analysis and hypotheses

Hypothesis	Association with positive well-being/competencies	Association with negative well-being/problem behaviors
1. Classes having high levels of symptoms and problems will have mean scores on the AICA-S consistent with a classification of IGD	N/A	N/A
2. Age, sex and country will be associated with classes	N/A	N/A
3. IGD classes (i.e., those with high levels of symptoms and problems) will have poor psychosocial well-being	–	+
4. The Normative class will have the least association with poor psychosocial well being	+	–
5. Classes with moderate to high problems will have poor psychosocial well-being compared to the Normative class	–	+
6. The Engaged class will not have poor psychosocial well-being	+	–

A plus sign indicates that a positive association is hypothesized; a minus sign indicates that a negative association is hypothesized

Table 2 Rate of endorsement of latent class indicators in full sample ($N = 7865$). An item was said to be endorsed if it was answered at the level of Often or Very Often

Item	Variable name	*n*	%
Symptom criteria			
Preoccupation	*preoccupation*	999	12.8
Escape	*escape*	843	10.9
Craving	*crave*	828	10.6
Felt you had played too long	*too long*	823	10.6
Ever tried to quit or limit[a]	*tried to limit*		
…If tried to limit, was *not* successful	*can't limit*	1154	15.3
…If tried to limit, was successful	*can limit*	2686	35.6
…Never tried to limit	*never limit*	3697	49.1
Cannot control gaming time	*locplaymore*	777	9.9
Forgot something important because of gaming	*forgot*	591	7.6
Tolerance	*tolerance*	540	6.9
Cannot resist compulsion to play	*resist*	485	6.2
Withdrawal	*withdrawal*	433	5.5
Problem criteria: Problems with…			
…work/school	*P_wk/sch*	1636	21.3
…neglecting leisure	*P_leis*	1583	20.6
…family	*P_fam*	1390	18.1
…health	*P_hlth*	1243	16.2
…neglecting friends	*P_frnd*	944	12.3
…money	*P_mon*	476	6.2

[a]Due to the binary wording of this question ("have you ever tried to limit"), this scale question was converted into the response types listed to appropriately capture the conditional nature of the question; the resulting three categories (could limit, can't limit, never limit) were used in analysis. Of the original first part of that question, 4054 participants (52.3%) answered that they had tried to limit gaming, and 798 participants (10.3%) answered at Often or Very Often

equality of means across latent classes in Mplus using the BCH procedure [36]. To assess divergent validity, we conducted an exploratory analysis to compare mean scores on the Internet Addiction Test across classes. To test **Hypothesis 2** and replicate the control covariates used in the previous study [29], we used separate latent class regression with auxiliary variables (R3STEP) in Mplus to test associations between demographic covariates and the odds of membership in each latent class compared to membership in the largest class. We used the same auxiliary variable approach to test **Hypotheses 3, 5 and 6** regarding the association between psychosocial variables and latent class using each scale or subscale score of the YSR as a covariate, controlling for age, sex and country. Because we used the Normative class as the reference class in our regressions, to test **Hypothesis 3** we again used the BCH

procedure to compare YSR mean scores in the Normative class to those in other classes. We also conducted unregistered exploratory analyses to test model assumptions about measurement invariance by sex and by latent class regression subsample. Data cleaning, validation and variable creation were performed in Stata 13.1 IC [37] and other analyses were performed in Mplus 7.31 [37]. Missing data were handled with Full Information Likelihood estimation for latent class analysis and mean difference testing and with listwise deletion for latent class regression.

As statistics, odds ratios are excellent predictors of non-chance associations, but are not easily interpretable as effect sizes, especially when small [39–40]. This is often the case in psychiatric research, where many different risk factors are thought to act together to contribute to the development of disorder [41]. Therefore, in this paper, when we discuss the significance of effects, we have chosen conservative estimates of association and will refer to effects as tiny (0.95 and 1.05 [39]), or small (0.54–0.94 or 1.05–1.85), medium (0.33–0.53 or 1.86–2.99), or large (less than 0.33 or 3 or greater) [42].

Results

Of the 13,460 valid responses, 7937 (59%) played video games at least once per month and were considered regular gamers, and of those, 7865 (58%) had at least one latent class indicator and were included in the latent class analysis. Missing data were generally less than 2% for symptom criteria and less than 3% for problem criteria. The average age of the sample was 15.8 years and 62.9% of the sample was male. The distribution of latent class indicators for the latent class analysis sample is shown in Table 2. Using the chosen cutoff of Often or Very Often for all symptoms except "Ever tried to quit or limit", most items were endorsed by less than 1/4 of the sample.

Latent class analysis

In the first latent class analysis conducted prior to the registration of our study, we found that a five-class model fits the data best. In this paper, we first changed our indicator for the *limit* question to capture the conditional nature of that question as described above, then performed latent class analysis anew for two through eight classes in the combined sample of males and females as described in the registered protocol. Model fit statistics (Table 3) showed that while BIC decreased continually, new classes did not add qualitatively different findings after the five-class model, which also had better entropy and more distinct classes than later models. Thus, this model was chosen. We then conducted unregistered exploratory analyses to determine whether these classes were the same (1) for males and females and (2) for the full sample as compared to the subsample having information on well-being variables that were included in the regression (i.e., the regression subsample). In both cases, models were somewhat different from the model discussed here. The main differences are presented in the text; results of all exploratory analyses are presented in the Supplementary material Appendix.

Figure 1 depicts the conditional probability of endorsement at the level of Often/Very Often (i.e., the statistical probability of a positive response) for each indicator by class. Of the five classes, only two classes had similar probabilities of endorsing symptom criteria and problem criteria, the classes we labeled *Normative* and *IGD*.

The largest class (61.8%) was labeled the *Normative* class as it was characterized by low probabilities of endorsing symptom criteria or problem criteria. In other words, video gamers in this class were unlikely to endorse any of the criteria for IGD. The smallest class (2.2%), which we labeled the *IGD* class, was characterized by high probabilities of endorsing both symptom criteria and problem criteria.

We also found a class that we labeled the *Concerned* class (23.6%), where the likelihood of endorsing most

Table 3 Latent class model selection in primary sample ($n = 7865$)

Number of classes	# of parameters	BIC	Entropy	LMR p value	Log likelihood	Estimated prevalence							
						C1	C2	C3	C4	C5	C6	C7	C8
2	35	84798.03	0.86	0.00	− 42297.65	78.4%	21.6%						
3	53	82140.36	0.80	0.00	− 40916.68	9.6%	26.3%	64.1%					
4	71	81467.27	0.82	0.00	− 40528.00	23.7%	5.0%	7.8%	63.5%				
5	**89**	**81278.22**	**0.82**	**0.01**	**− 40381.35**	**5.1%**	**2.2%**	**7.3%**	**61.8%**	**23.6%**			
6	107	81105.69	0.80	0.00	− 40242.95	5.6%	56.4%	2.1%	2.0%	5.9%	27.9%		
7	125	80987.05	0.79	0.04	− 40131.50	1.4%	1.9%	5.8%	7.7%	2.1%	25.5%	55.5%	
8	143	80973.75	0.77	0.72	− 40072.72	5.7%	8.8%	56.0%	1.4%	2.0%	6.5%	17.9%	1.8%

Bold indicates chosen model

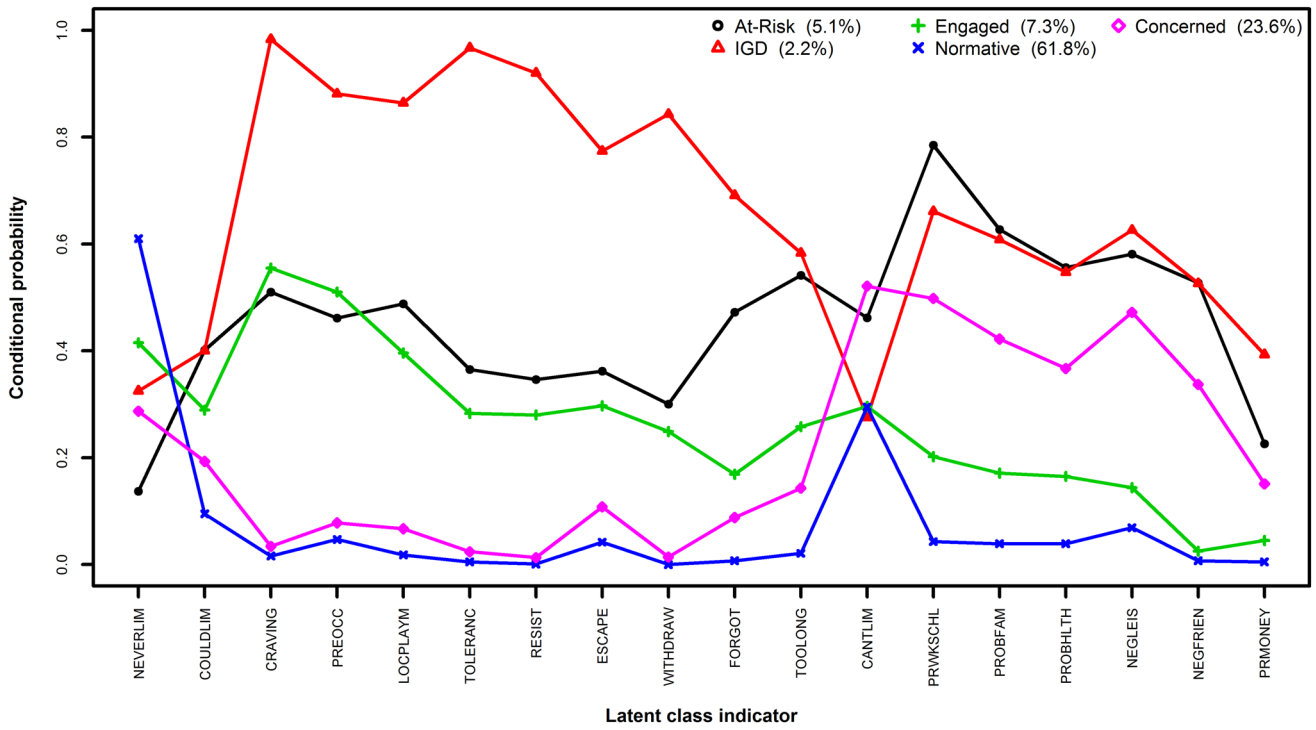

Fig. 1 Latent class model results ($n = 7865$)

symptom criteria was on par with the Normative class, yet individuals estimated to be in the *Concerned* class were more likely to have felt that they played too long, tried to limit their gaming but were unable to do so, and used games to escape negative feelings. However, unlike the Normative class, the probability of endorsing most problem criteria was higher for *Concerned* gamers. This group might reflect adolescents who experience few to no symptoms but feel that their gaming has caused problems in various life domains.

The final two classes reported symptom criteria at moderate levels, but their endorsement of problem criteria diverged. In the class labeled *At-Risk* (5.1%), symptom endorsement was moderate and well below that of the IGD class, yet problem endorsement was virtually the same as the IGD class. In comparison, the class labeled *Engaged* (7.3%) endorsed most symptom criteria at a level similar to that of the At-Risk class, yet endorsed problem criteria at a much lower rate. We labeled this class as Engaged because these gamers seem to experience some criteria of IGD without experiencing life interference or impairment. Of note, our At-Risk class had higher probabilities of forgetting to do other things while gaming, feeling that they played for too long, and feeling that they were not able to limit their gaming time compared to the Engaged class, suggesting that the At-Risk class feels more loss of control.

Validity testing of classes

To assess convergent validity in **Hypothesis 1**, we compared means for the summed AICA-S across latent classes, including within sex-specific classes, using established cut-off scores of 13.5–27 = IGD and 7–13 = At-Risk [29]. We found support for the validity of our classes in samples where sexes were combined and in males, but found some important differences for females (Supplementary material Appendix, Table A7). In the combined sample and in males, the IGD class score was 17.7 and 17.8, which would be correctly classified as IGD [29]. For females, the average score in the IGD class was 10.6, meaning that females, although endorsing both symptoms and problems together, would be classified as At-Risk rather than IGD. Contrary to our expectations, both the At-Risk and Engaged classes would be classified as at-risk of having IGD. The average scores for the At-Risk class were 10.0 (combined) and 10.1 (males). The average scores for the Engaged class, which reported symptoms but few problems, were 7.6 (combined) and 7.8 (males only). Although the Concerned class reported similar levels of problems as the At-Risk class, they fell below the cut-off of 7 points. Overall, we found that while our IGD and At-Risk classes seemed consistent with scale score classification of IGD, our Engaged class would have been classified as At-Risk despite having few problems and our Concerned class,

which reported problems on par with the At-Risk, would have been identified as non-problematic.

To assess divergent validity, we tested for mean differences in Internet Addiction Test scores between classes (Supplementary material Appendix, Table A7). Only the IGD and At-Risk classes fell within the cutoff on the Internet Addiction Test, with average scores in the at-risk range from 42.8 (Males At-Risk class) to 54.7 (IGD, primary sample). Overall, this provides support for some overlap between Internet addiction and IGD, but demonstrates that our results do not simply represent Internet Addiction itself.

Predictors of class membership

As many participants (including all German students [43]) did not have data for the YSR variables, our latent class regression subsample was limited to 5985 students. The best-fitting model in this subsample had four classes that were similar to the original classes. We labeled these classes IGD (4.9% of our subsample), Engaged (7.6%), Concerned (24%), and Normative (63.5%). In our tests of **Hypothesis 2**, we found that male sex and country predicted the odds of membership in the IGD class (compared to the Normative class) while Engaged class membership was predicted by male sex only (Supplementary material Appendix, Table A8). The Concerned class was reliably predicted by age and country.

Association between classes and psychosocial well-being

Hypothesis 3 regarding the expected poor well-being of the IGD class was supported. As scores in competencies of academics, activities and social situations increased, the odds of membership in the IGD class compared to the Normative class decreased, with effect sizes ranging from small to medium. As scores on problem scales such as attention, withdrawn/depressed and social problems increased, the odds of membership in the IGD class increased, but effect sizes were small. All associations were statistically significant at Bonferroni-corrected levels and were higher in magnitude than those of the other classes (Table 4). We also found support for **Hypothesis 5** regarding the poor well-being of any other classes having moderate to high levels of problems (in this case the Concerned class). All associations were lower in magnitude than those of the IGD class. However, we found almost no support for **Hypothesis 6**, the lack of association between the Engaged class and poor well-being. Compared to the Normative class, membership in the Engaged class was positively associated with all scales and subscales of poor well-being. However, these associations

Table 4 Predictors of gaming-related latent class membership among 5985 European adolescents

	IGD, 4.9%		Engaged, 7.6%		Concerned, 24.0%	
YSR score (range)						
Competencies						
Total competence (0–45.5)	0.91*	(0.90–0.93)	0.97	(0.95–0.99)	0.94*	(0.92–0.96)
Academics[a] (0–3)	0.36*	(0.29–0.46)	0.84	(0.65–1.09)	0.51*	(0.44–0.60)
Activities (0–8)	0.90*	(0.86–0.93)	0.95*	(0.91–0.99)	0.95*	(0.93–0.97)
Social competence (0–65)	0.87*	(0.82–0.92)	0.99	(0.93–1.05)	0.88*	(0.84–0.91)
Problems						
Total problems (0–210)	1.07*	(1.07–1.07)	1.04*	(1.04–1.04)	1.05*	(1.05–1.05)
Externalizing (0–133)	1.19*	(1.16–1.21)	1.09*	(1.07–1.12)	1.12*	(1.09–1.14)
Internalizing (0–79)	1.19*	(1.16–1.21)	1.08*	(1.06–1.10)	1.12*	(1.09–1.14)
Aggression (0–90)	1.31*	(1.26–1.36)	1.14*	(1.12–1.16)	1.19*	(1.16–1.21)
Anxiety/depression (0–55)	1.32*	(1.27–1.38)	1.13*	(1.08–1.17)	1.21*	(1.19–1.23)
Attention (0–27)	1.48*	(1.42–1.54)	1.22*	(1.17–1.27)	1.28*	(1.23–1.34)
Rule-breaking (0–65)	1.32*	(1.27–1.38)	1.19*	(1.14–1.23)	1.22*	(1.20–1.25)
Social problems (0–22)	1.54*	(1.45–1.63)	1.26*	(1.19–1.33)	1.35*	(1.30–1.40)
Somatic complaints (0–65)	1.42*	(1.36–1.48)	1.15*	(1.08–1.22)	1.26*	(1.21–1.31)
Thought problems (0–24)	1.36*	(1.31–1.42)	1.21*	(1.16–1.26)	1.22*	(1.20–1.25)
Withdrawn/depressed (0–16)	1.54*	(1.48–1.60)	1.20*	(1.13–1.27)	1.30*	(1.25–1.35)

Regressions comparing each latent class to the Normative class were modeled separately for each well-being predictor controlling for age, sex and country using Bonferroni-corrected p value of 0.006

Statistically significant results are indicated with an asterisk. Estimates are the odds of membership in the designated class compared to the Normative class for each unit increase in predictor

[a]The Academic subscale has a limited range (0–3) by design

were lower in magnitude than those of the other classes; the odds ratio of 1.04 for the Total Problems scale could be considered "tiny" [39]. In addition, the Engaged class showed impaired competencies only in the Activities subscale, again with a "tiny" odds ratio of 0.95. This suggests that while the Engaged gaming class reports little significant impairment in competencies related to gaming, they may have slightly higher levels of psychosocial problems.

To test **Hypothesis 4**, we compared means of psychosocial well-being variables in the Normative class to those of other classes using Bonferroni-corrected p values of $p < 0.008$ to account for the overall test and post hoc pairwise comparisons. Our hypothesis that the Normative class would show the best well-being was mostly supported. Except for Social Competence, the Normative class had the highest means on YSR competencies and the lowest means on YSR variables indicative of poor well-being (Supplementary material Appendix, Table A9).

Overall, our analysis showed that three classes met the biaxial model of addiction, but two did not, and that classification based on IGD scale scores did not match the levels of problems related to gaming in these classes (Table 5). We found support for most of our hypotheses about classes and well-being except those related to the Engaged class, which was found to have small but significant associations with all psychosocial problems yet little impairment.

Discussion

In our study of European adolescent gamers, we found that when we looked for subgroups of respondents using a rigorous person-centered approach, we were able to identify five different underlying groups and support some, but not all of our pre-registered hypotheses about these groups. These groups would not be apparent if we had assumed homogeneity across all gamers in the community population, and suggests that using a traditional variable-centered survey assessment that does not require the biaxial model of addiction to be fulfilled may lead to more than 30% of gamers being misclassified.

IGD and At-Risk gamers

Our analysis showed that endorsement of IGD symptom criteria (e.g., preoccupation, tolerance, loss of control, and withdrawal) and reporting of problem criteria related to gaming (e.g., difficulty in school or with family) corresponded closely in only two groups: the IGD class, which was very likely to experience both symptom criteria and problem criteria and the Normative class, which was unlikely to experience either. The IGD class satisfies the biaxial model of addiction: both symptom criteria and problem criteria were highly endorsed. Validation of both IGD and Normative classes shows that they would be accurately classified by an IGD scale. The prevalence of 2.2% for this class is on par with other studies using latent class analysis [44, 45] as well as studies using clinician evaluation [46] or polythetic scoring [48–49] in community populations of adolescents worldwide, and is very close to the 2.7% prevalence reported previously in this sample [29]. Overall, the IGD class satisfies the biaxial model of addiction and shows consistency with the construct of IGD as has been proposed in DSM 5. Our **Hypothesis 3** was upheld in this class, which experienced poor well-being compared to the Normative class, with effect sizes ranging from small to medium.

The At-Risk class was somewhat similar to the at-risk for IGD construct as described in prior studies; however, our

Table 5 Synthesis of analysis results by class

	Conditional probability in latent class of		Satisfies biaxial model?	Classification according to AICA-S[a]	Demographic associations[b]	Psychosocial well-being	
	Symptoms	Problems				YSR competencies	YSR problems
Class name							
IGD	High	High	Yes	IGD	Male	4/4 low[c]	High
At-risk	Mod	High	Yes	At-Risk	N/A	N/A	N/A
Concerned	Low	Mod-High	No	Non-PG	Age, country	4/4 low	High
Engaged	Mod	Mod-Low	No	At-Risk	Male	1/4 low	High
Normative	Low	Low	Yes	Non-PG	(Reference)[d]	(Reference)	(Reference)

Mod moderate, *Non-PG* non-problematic

[a]AICA-S scored according to Müller et al. (2015) and compared with mean difference testing across classes

[b]Results for multivariate analyses

[c]Four scores were available for competency domains; 1/4 low indicates that only one competency was low/impaired. All YSR problem scales and subscales were elevated in all non-normative classes

[d]Normative class was used as the reference class in regressions

At-Risk class had moderate symptoms yet an equal likelihood of problems as the IGD class. This class would also be classified as being At-Risk for IGD according to traditional scoring of the IGD measure used here. Rather than simply appearing to be a quantitatively less severe form of IGD, we see a qualitative difference: the greater burden for this group may come from gaming-related problems that may not be well captured by symptom criteria. Therefore, if this group was given a measure that did not require endorsement of problems related to gaming (i.e., a symptoms-only measure without a strong focus on impairment), their potentially problematic gaming might be overlooked. The existence of this group supports calls for inclusion of an impairment requirement for IGD and behavioral addiction in general [11].

Engaged and Concerned gamers

The Engaged and Concerned classes provide unexpected information. Although Engaged gamers have been described in prior literature as a group experiencing few psychosocial problems or even better psychosocial well-being [45, 50], we find that our group of Engaged gamers reported slightly poorer psychosocial well-being compared to the Normative class. However, even though this class does not demonstrate high probabilities of gaming-related problems, the average score of the AICA-S in this group shows that they would be classified as being at risk for disorder. One potential explanation for this discrepancy between gaming-related impairment and psychosocial problems is that Engaged gamers successfully use games to cope with difficult situations or life circumstances. For example, gaming may help individuals connect socially, providing opportunities for friendship and social support and reducing depressive symptoms [50, 51]. If this is the case, Engaged gamers would be less likely to benefit from interventions aimed at reducing or restricting gaming, and lessening this group's opportunity to cope by restricting gaming could be more harmful than helpful. It is concerning that this class would be classified as being at risk of disorder, as it suggests they may end up with treatment focused on limiting gaming rather than improving underlying problems. Once more, this highlights the importance of including an impairment requirement for clinical and population-based assessments of gaming-related problems.

However, another potential explanation is that this class denies harm. Previous qualitative work has uncovered a "no harm discourse" wherein some adolescents normalize excessive online behavior and associated consequences [52]. Mixed methods or multiple rater approaches may be useful in clarifying whether this is the case, drawing in particular on qualitative work with gamers who are highly engaged as well as those reporting significant problems with gaming [53]. Such approaches might also clarify the phenomenology of IGD and improve assessment criteria for the next revision of DSM-5.

The Concerned class represents a large subgroup (23.6%) that seems to have been overlooked in previous literature and is not captured by common IGD assessment scales. This group sees gaming as causing problems in many life areas and reports poorer well-being than both Normative and Engaged gamers, yet reports low levels of addiction-related symptoms. Our expectation for **Hypothesis 5** was upheld here; this class reported poorer well-being than the Normative class and had slight negative associations with competencies. However, despite reporting high levels of gaming-related problems, individuals in this class do not satisfy the biaxial model of addiction and were not identified as at-risk for IGD by traditional scoring. This group might consist of adolescents who experience few to no addiction-related symptoms of IGD, but feel that their gaming is causing problems in various life domains. These adolescents may have more competing demands in terms of role responsibilities or expectations and, therefore, any interference from gaming is more salient. This may be related to being older or having greater obligations in school or at home, or could be related to the attitudes, concerns, or expectations of family members or others about the normality of video game play or its effects on what is judged to be a healthy lifestyle. This would echo concerns expressed by some researchers that the discourse around gaming as disordered or addictive may contribute to a moral panic that will make life more difficult for young gamers due to external pressure [54]. More research into this Concerned class would be beneficial to understand why they experience no addiction-related symptoms but still endorse a higher level of problems related to their gaming.

Another possibility is that these adolescents may have greater insight than others into the problematic outcomes that occur because of gaming, perhaps as an adaptive form of self-regulation after previously experiencing significant life problems associated with gaming. In fact, several studies suggest that problematic gaming is a transient state, resolving quickly in up to 50% of gamers [45, 55, 56]. This indicates support for the possibility that criteria for IGD may even lack sensitivity as well as specificity and suggest that survey instruments containing only symptom criteria will likely fail to capture a substantial group of gamers who have problems from their gaming. Future criteria development should ensure that the distinct experiences of all groups of gamers are appropriately accounted for, which could be accomplished by a stronger focus on the phenomenology of disordered gaming [57]. Finally, it is also important to note that being male is less likely in this class than in the IGD and Engaged classes, so this class may represent a previously unexamined aspect of IGD that is different for females. These findings support the importance of considering sex-specific norms for both gaming and IGD scales and

the importance of ensuring that interventions and treatments are accessible to both sexes.

Although our study used rigorous and transparent methods to test specific hypotheses about associations between problematic gaming and well-being, it has limitations. The cross-sectional nature of our data prevents any ability to make causal inferences. Inconsistencies in test administration between countries led to dissimilar samples between our latent class analysis and latent class regression. However, this challenge was also present in the original study [29], and our well-being findings for the IGD class are similar to those of other studies as well [58]. Finally, most effects between well-being and our latent classes were small, with a few in the "tiny" range. While this is most likely due to the complex causal architecture underlying health conditions at a population scale [59], it reinforces the idea that there are unlikely to be simple one to one relationships between difficulties related to video game play and problems with well-being.

Conclusions

Our novel approach to seeking subgroups of gamers that do or do not satisfy the biaxial model of addiction, combined with rigorous and transparent hypothesis testing and validation, suggests that the current formulation of IGD may work when capturing extreme cases of disordered gaming but might lead to inappropriate classification and treatment for some (Engaged gamers), while failing to identify potential problems for others (Concerned gamers). Based on our findings for those two groups, almost a third of gamers may be labeled incorrectly if traditional approaches to IGD classification such as scale score cut-offs are used.

We recommend that future population-based assessment instruments for IGD or similar disorders require problem criteria for classification. Furthermore, we recommend that clinicians and researchers consider the concerns of gamers who feel their gaming is out of control or problematic but report few addiction-related symptoms, as well as those gamers who report few gaming-related problems, yet report psychosocial problems in other areas. For the first group, interventions that support gamers to moderate their gaming habits may be helpful, but for the second group gaming may be serving a useful function, and interventions aimed at moderating gaming habits may be inappropriate or even harmful. Identifying the phenomenology of disordered gaming and its demarcation from highly engaged gaming will allow progress in the study of potential behavioral addictions and their appropriate assessment, prevention and treatment. Future studies should be conducted in accordance with an open science framework to ensure continued transparency and methodological rigor.

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Compliance with ethical standards

Conflict of interest On behalf of both authors, the corresponding author states that there is no conflict of interest.

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