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Gaming passion contributes to the definition and identification of problematic gaming

Alexandre Infanti [a], Carlos Valls-Serrano [b], José C. Perales [c], Claus Vögele [a], Joël Billieux [d,e,*]

[a] Department of Behavioural and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzette, Luxembourg
[b] Department of Psychology, Catholic University of Murcia, Murcia, Spain
[c] Department of Experimental Psychology, Mind, Brain and Behavior Research Center (CIMCYC), University of Granada, Granada, Spain
[d] Institute of Psychology, University of Lausanne, Lausanne, Switzerland
[e] Centre for Excessive Gambling, Addiction Medicine, Lausanne University Hospitals (CHUV), Lausanne, Switzerland

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ABSTRACT

Even if for most people playing video games is a healthy leisure activity, a minority of vulnerable users present an excessive use associated to negative consequences (e.g., psychosocial maladjustment, sleep interference) and functional impairment. The current study first aims to identify psychological factors that contribute to discriminate highly involved (but healthy) gamers from problematic gamers. For that purpose, we used a cluster analysis approach to identify different groups of gamers based on their profiles of passion towards gaming (using the Dualistic Model of Passion). Another objective of the present study is to explore, using supervised machine-learning, how gaming disorder symptoms, assessed within the substance use disorder framework (e.g., tolerance, withdrawal), might be linked to harmonious and/or an obsessive passion for gaming. Three distinct clusters of gamers were identified based on their passion profiles, including risky gamers, engaged gamers, and casual gamers. Supervised machine-learning algorithms identified that specific gaming disorder symptoms (salience, mood modification, tolerance, low level of conflict) were predominantly related to harmonious passion, whereas others (withdrawal, high level of conflict, relapse) were more directly related to obsessive passion. Our results support the relevance of person-centered approaches to the treatment of problematic gaming.

1. Introduction

1.1. Background

Video games are a leisure activity practiced by around 3.2 billion people worldwide (Newzoo, 2022). It is thus a widely spread activity that can take place on several platforms, from computers to smartphones. Even if for most people playing video games is a non-problematic leisure activity, a minority of users show excessive use associated with ill-health (e.g., addiction symptoms, psychosocial maladjustment, sleep interference, health issues) and functional impairment (Jo et al., 2019; Männikkö et al., 2020; Reed et al., 2022).

In 2013, for the first time Internet Gaming Disorder was considered as a potential emerging condition and included as a "condition for further study" in the fifth version of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association [APA], 2013). In the DSM-5, the criteria used to diagnose Internet Gaming Disorder include those of substance use disorder (e.g., withdrawal, tolerance, continue despite problems) and gambling disorder (e.g., deceiving, escape adverse mood) (Petry et al., 2014). At that time, the risk of excessive pathologizing was tentatively addressed by suggesting a higher threshold (i.e. number of criteria necessary to diagnose the condition) than the one recommended by the DSM-5 (Lemmens et al., 2015). More recently, Gaming Disorder (GD) has been recognized as a psychiatric condition and has been listed as a "disorder due to addictive behaviors" in the 11th edition of the International Classification of Diseases (World Health Organization [WHO], 2019). Crucially, the WHO followed a more conservative approach and proposed that GD is characterized by three mandatory features (loss of control, increasing priority given to gaming, and continued use despite negative consequences) associated with clinically relevant functional impairment (Reed et al., 2022). In contrast, the most recent version of the DSM-5 (DSM-5 TR) neither includes an updated definition of GD nor recognizes it as a disorder (First et al., 2022).

Given the recency of the ICD-11 framework for GD, the largest part of problem gaming research of the last decade was based on DSM-5 criteria

* Corresponding author at: Institute of Psychology, University of Lausanne, Quartier UNIL-Mouline, CH-1015 Lausanne, Switzerland. Phone: (+41) 21 692 32 54.

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to assess GD. However, a growing body of literature shows that some substance use disorder or gambling disorder criteria – typically withdrawal and tolerance, preoccupation, mood regulation, or deception – are not necessarily relevant in the context of problematic gaming (Castro-Calvo et al., 2021; Deleuze et al., 2017, 2018; Ko et al., 2014; Müller et al., 2019; Peeters et al., 2019; Rehbein et al., 2015). These criteria largely fail to discriminate between intensive but non-problematic and pathological involvement in video games (Billieux et al., 2019; Charlton & Danforth, 2007), thus promoting the pathologizing of gaming behavior (Kardefelt-Winther et al., 2017). In this context, it is important to elucidate the mechanisms involved in high – but non-problematic – involvement versus problematic involvement in video games, to eventually contribute to refine and improve the diagnosis, assessment, and treatment of GD. Ultimately, acknowledging the difference between problematic and non-problematic intense involvement in video gaming would contribute to reduce the stigma around the concept of GD.

1.2. The Dualistic model of passion

The Dualistic Model of Passion proposed by Vallerand (2010, 2015) is a sound framework to investigate the distinction between high – but non-problematic – involvement and problematic involvement in video games. Vallerand's framework posits a distinction between so-called "harmonious" and "obsessive" passions. Harmonious passion is the result of an autonomous internalization of a given activity into one's identity. People with harmonious passion have a strong connection with an activity, but this does not interfere with other aspects of their lives. Harmonious passion is associated with mindful engagement instead of unregulated urges. In harmonious passion, the activity is performed with a secure sense of self-esteem, openness, and flexibility. In contrast, obsessive passion refers to controlled internalization of a given activity into the person's identity. This type of internalization is due to some intra- and/or interpersonal forces because of contingencies related to the activity (feelings of social acceptance, self-esteem), or because the excitement produced by the activity becomes uncontrollable. Obsessive passions are central in the life of individuals and are associated with a passive attitude; they "enslave" people who become controlled by their passion and cannot regulate their engagement. In this case, the activity typically conflicts with various areas of life (e.g., professional, social). As a result, people exhibiting obsessive passions present an uncontrolled and inflexible involvement, which ultimately promotes negative consequences and, in extreme cases, functional impairment. There is evidence that obsessive passion for video games is associated with negative outcomes (Bertran & Chamarro, 2016; Mills et al., 2018) and problematic and deregulated usage patterns (Lafrenière et al., 2009; Wang & Chu, 2007). Also, gamers with an obsessive passion report high levels of loneliness, reduced well-being (Mandryk et al., 2020), and tend to play to escape daily problems (Bertran & Chamarro, 2016). In contrast, harmonious passion operates as a protective factor against gaming-related negative consequences. Indeed, harmonious passion was associated with better life satisfaction, post play energy, and higher game enjoyment (Przybylski et al., 2009). Also, harmonious passion was associated with lower levels of loneliness and higher well-being (Mandryk et al., 2020). Nevertheless, both types of passions also have commonalities. For example, Lafrenière et al. (2009) showed in a sample of gamers that both harmonious and obsessive passions are associated with a positive experience toward gaming. Along the same lines, time spent on gaming is positively associated with both types of passion (Lafrenière et al., 2009; Mills et al., 2018; Przybylski et al., 2009), reinforcing the view that time spent gaming is not a good indicator of problematic gaming (Király et al., 2017; Skripkauskaite et al., 2022). Furthermore, playing for immersion purposes and obsessive passion constitute important predictors of problem gaming symptoms, which is not the case for self-reported gaming time (Kneer & Rieger, 2015). These findings were confirmed by a recent longitudinal study using objective playtime indicators (behavioral tracking) showing that (1) actual time spent gaming did not correlate with problem gaming symptoms and quality of life and (2) self-reported gaming time was on average 10h per week longer compared to objective gaming time (Larrieu et al., 2023). Taken together, these results suggest that (self-reported) time spent gaming is not a valid indicator (or even a proxy) of problematic gaming.

1.3. Present study

Against this background, the current study combines a person-centered and a variable-centered approach to pursue two main objectives (Fig. 1). The person-centered approach (first objective) was designed to identify the psychological factors that discriminate highly involved (but healthy, i.e., non-problematic) gamers from problematic gamers. These results may provide useful information to avoid pathologizing intensive but healthy gaming patterns and for the design of tailored treatment or prevention interventions. The variable-centered approach (second objective) was used for the evaluation of GD criteria. The aim here was to identify the most discriminative criteria for the detection of a potential GD.

The first objective was implemented by using a cluster analysis approach to identify different gamer groups (i.e., clusters) based on their profiles of passion towards gaming (using the theoretical framework of Vallerand described previously). The purpose in choosing these two variables for the cluster generation was to identify different passion profiles among gamers, and to compare them in terms of relevant external criteria. Such person-centered approach was used as it allowed us to consider how both types of passion co-exist or not in the same person, and how this affects the functional or dysfunctional nature of gaming behaviors. Based on previous research on problematic gaming, the external criteria considered included GD symptoms, gaming motives, and impulsivity traits. We focused on gaming motives and impulsivity as these two psychological dimensions have been extensively explored in the context of problematic gaming (Király et al., 2022; Şalvarlı & Griffiths, 2022). Gaming motives such as escapism (e.g., the desire to evade everyday worries), coping (e.g., playing to cope with adverse moods), fantasy (e.g. the interest in stepping out of the own identity and creating a new one far from reality), competition (e.g. achievement purposes), or skill development (e.g. playing to improve abilities like coordination) have been related to problematic gaming (Bäcklund et al., 2022; Ballabio et al., 2017; Bányai et al., 2019; Biolcati et al., 2021; Columb et al., 2023; Laconi et al., 2017; Melodia et al., 2022; Rafiemanesh et al., 2022; Šporčić and Glavak-Tkalić, 2018; Wu et al., 2017). Regarding impulsivity, several studies have found that impulsivity traits positively correlate with the severity of problematic gaming symptoms (Ding et al., 2014; Ryu et al., 2018). Some authors also argued that impulsivity could be a risk factor regarding the transition from recreational to problematic gaming (Raybould et al., 2022). Moreover, the negative urgency impulsivity trait has been identified as a predictor of comorbidity between ADHD and GD in a sample of outpatients diagnosed *a posteriori* using the new ICD-11 criteria (Cabelguen et al., 2021).

The second objective of this study was variable-oriented. We explored how gaming disorder symptoms, assessed within the substance use disorder and gambling frameworks (e.g., tolerance, withdrawal, preoccupation, mood modification), are linked to harmonious and/or an obsessive passion for gaming. For the second objective we used supervised machine learning to identify which GD criteria/symptom predict either a harmonious or an obsessive passion.

2. Method

2.1. Participants

Participants were recruited from four Spanish universities (the Catholic University of Murcia, the University of Granada, the University

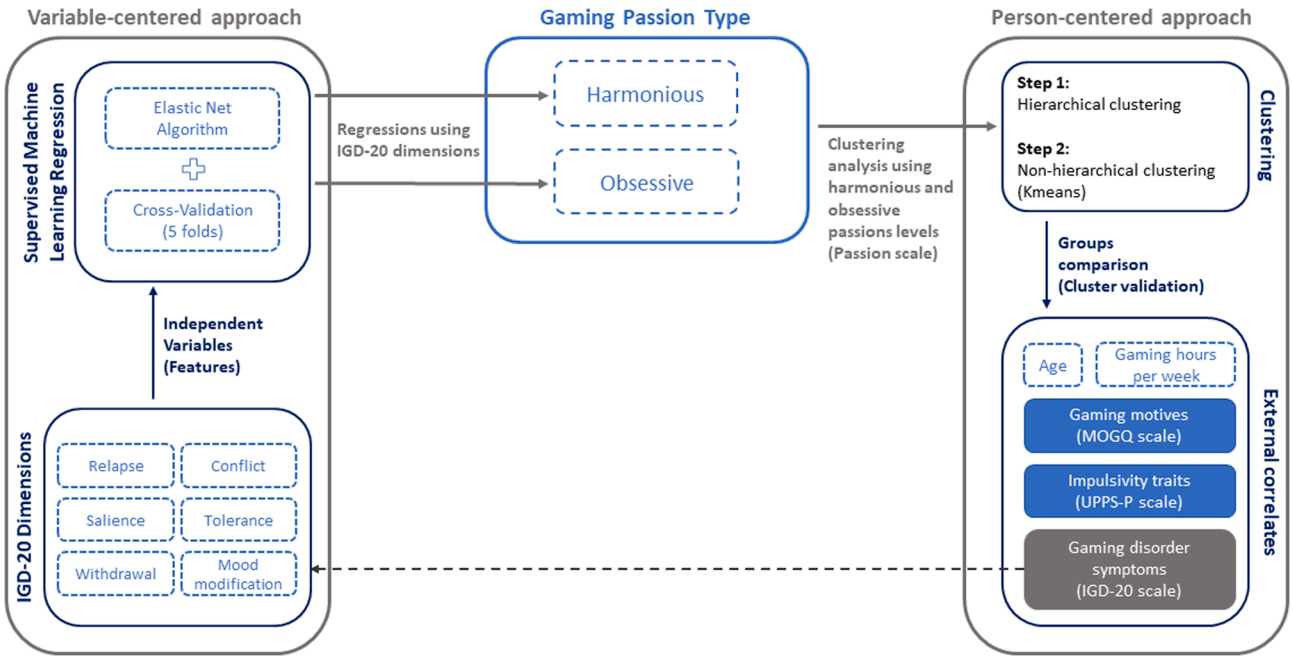

Fig. 1. Methodological *approach.*

of Extremadura, and the University of the Basque Country). The study consisted of an online survey and potential participants were invited by email. Confidentiality was guaranteed and participants were requested to give their online consent to participate after being informed about the aims of the study. Participants were required to report playing video games at least two hours per week and to be at least 18 years of age to be included in the study. Five gift cards of 15€ were raffled at the end of the study as an incentive for participation. A total of 1130 participants started the completion of the online survey. Participants were excluded if they had at least one missing data point on one of the study's variables (n = 133), did not met the inclusion criteria (n = 48), or if they provided invalid information such as playing more than seven days per week or more than 24 h per day (n = 104). The final sample consisted of 845 participants. Participants were aged between 18 and 50 years (M = 23.5, SD = 5.03). Gender distribution and gaming preferences are reported in Table 1. In the final sample, 11 participants were identified as disordered gamers according to the IGD-20 (cut-off score of 71) (Pontes et al., 2014). The study was conducted in accordance with ethics for human research in the Declaration of Helsinki and was approved by the Ethics Committee of the Catholic University of Murcia (CE031905).

2.2. Measures

The Passion Scale (Marsh et al., 2013) was of central importance for the current study as we used it to generate groups of gamers through a cluster analytical approach (see data analytic strategy section). This scale is composed of 12 items answered on a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). Among the 12 items, six assess harmonious passion, and six assess obsessive passion. Participants are asked to think about their gaming activity. Harmonious passion is evaluated using items such as *"This activity is in harmony with the other activities in my life"*, or *"This activity allows me to live a variety of experiences"*. In contrast, obsessive passion is evaluated with items such as "*I have almost an obsessive feeling for this activity"*, or *"This activity is the only thing that really turns me on*". For the present study, we used the validated Spanish version of the passion scale (Chamarro et al., 2015) which presents good internal consistency. In the current sample, Cronbach's alpha was equal to 0.89 for obsessive passion and 0.87 for harmonious passion. Spearman's rank correlation between harmonious and obsessive passions was 0.37 (p <.001). This positive correlation can be explained by the fact that harmonious and obsessive passion are sharing some aspects related to the definition of passion such as considering the activity as a passion, giving some value to it, viewing it as integrated into the self, and dedicating time and energy to it (Vallerand et al., 2003). However, even if harmonious and obsessive passions belong to the same scale and are sharing common aspects related to passion, such correlation does not involve collinearity issues between these two variables which can be considered as distinct constructs for the cluster analysis.

The Motives for Online Gaming Questionnaire (MOGQ) (Demetrovics et al., 2011) is composed of 27 items assessing seven motives. Respondents are requested to use a 5-point Likert scale (1 = never; 5 = almost always/always). Gaming motives assessed include social (e.g., *"I play online games because I can get to know new people*"), escape (e.g., *"I play online games because gaming helps me to forget about daily hassles"*), competition (e.g.,"*I play online games because I enjoy competing with others*"), skill development (e.g.,"*I play online games because gaming sharpens my senses*"), coping (e.g.,"*I play online games because it reduces tension*"), fantasy (e.g.,"*I play online games to feel as if I was somebody else*"), and recreation (e.g.,"*I play online games because I enjoy gaming*"). The psychometric properties of the Spanish MOGQ will be described in another research report based on the same dataset. Confirmatory factor analysis for the Spanish MOPGQ can be obtained from the following Open Science Framework link (OSF, https://osf.io/jk94v/). In the Spanish MOGQ, escape and coping motives are regrouped in a single motivation dimension. Cronbach's alphas for the other dimensions in the present sample were 0.93 for general motivation, 0.79 for social, 0.91 for escape/coping, 0.85 for competition, 0.92 for skill development, 0.84 for fantasy, and 0.82 for recreation.

The Internet Gaming Disorder Test (IGD-20) (Pontes et al., 2014) assesses GD symptoms based on the DSM-5 framework and the "Components Model" of addiction (Griffiths, 2005). Each item is scored on a 5-points Likert scale (1 = strongly disagree; 5 = strongly agree). This questionnaire thus assesses GD symptoms within a substance-use based framework, through the following dimensions: salience (e.g., "*I usually think about my next gaming session when I am not playing*"); mood modification (e.g., "*I play games to help me cope with any bad feelings I might have*"); tolerance (e.g., "*I need to spend increasing amounts of time engaged in playing games*"); withdrawal (e.g., "*I feel sad if I am not able to play*

Table 1
Demographic *variables (N = 845)*.

		Mean (*SD*)	N (%)
Age		23.51 (5.03)	
Hours of gaming per day		2.02 (1.79)	
IGD-20		36.76 (11.86)	
Gender	Male		426 (50.41)
	Female		417 (49.35)
	Other		2 (0.24)
Educational level	Primary education		4 (0.47)
	Secondary education		15 (1.78)
	Vocational education and training		13 (1.54)
	Certificate of higher education		58 (6.86)
	Bachelor's degree		157 (18.58)
	University degree		439 (51.95)
	Master's degree		139 (16.45)
	Doctorate		20 (2.37)
Loot boxes consumption	Yes		194 (22.96)
	No		651 (77.04)
Playing on PC	Male		182
	Female		87
	Other		1
	Total		270 (31.95)
Playing on console	Male		159
	Female		61
	Other		0
	Total		220 (26.04)
Playing on portable / tablet	Male		85
	Female		269
	Other		1
	Total		355 (42.01)
Online	Yes		666 (78.82)
	No		179 (21.18)

Note. IGD-20 = Internet Gaming Disorder Test; PC = Personal Computer.

games"); conflict (e.g., "*I think my gaming has jeopardized the relationship with my partner*"); and relapse (e.g., "*I do not think I could stop gaming*"). For this study, the Spanish version by Fuster et al. (2016) was used. This version showed good psychometric properties (e.g., structural validity, internal reliability). In the current sample, Cronbach's alphas were 0.91 for the total score, 0.65 for the salience dimension, 0.63 for mood modification, 0.65 for tolerance, 0.76 for withdrawal, 0.71 for conflict, and 0.76 for relapse. Even if the scale is named "*Internet Gaming Disorder Test*", the items of the scale do not specifically refer to online gaming and can also refer to offline gaming.

The Short UPPS-P Impulsivity Scale (Billieux et al., 2012) contains 20 items that assess five distinct impulsivity traits, including negative urgency (e.g., "*When I am upset I often act without thinking*"), lack of premeditation (e.g., "*My thinking is usually careful and purposeful*"), lack of perseverance (e.g., "*I finish what I start*"), sensation seeking (e.g., "*I quite enjoy taking risks*"), and positive urgency (e.g., "*I tend to act without thinking when I am really excited*"). Items are scored using a 4-point Likert scale (1 = strongly agree; 4 = strongly disagree). The strength of the UPPS-P model of impulsivity is that it allows for a comprehensive assessment of the multi-faceted nature of impulsivity (Whiteside & Lynam, 2001). For this study, the Spanish version was used (Cándido et al., 2012). This version has good psychometric properties (structural and construct validity, internal reliability). In the current sample, Cronbach's alphas were 0.82 for negative urgency, 0.76 for lack of premeditation, 0.79 for lack of perseverance, 0.81 for sensation seeking, and 0.66 for positive urgency. Here we decided to group the negative and positive traits into a single urgency dimension, since it has recently been demonstrated that these two traits actually form a single coherent construct (Billieux et al., 2021). Cronbach's alpha for urgency was 0.81.

2.3. Data analysis

Following the recommendations by Hair et al. (2010), we performed cluster analysis by combining hierarchical and non-hierarchical approaches. Using both hierarchical and non-hierarchical methods allows for compensating weaknesses of each method by capitalizing on the advantages of the other (Hair et al., 2010). As explained earlier, the variables used to create the clusters were the obsessive and harmonious passions scores. Before performing the cluster analysis, we first ensured that there was no collinearity between the two variables composing the passion scale. We then scaled and centered the variables used for the generation of clusters. This was followed by hierarchical clustering using the Ward method with squared Euclidian distances to identify the optimal number of clusters to be used in the following non-hierarchical clustering. The NbClust R package (Charrad et al., 2014) was used to evaluate the best number of clusters to retain. This package uses the majority rule which is a simple method for selecting the optimal number of clusters based on the number of times a particular value of k is chosen as the best clustering solution by different clustering indices (kl, ch, hartigan, ccc, scott, marriot, trcovw, tracew, friedman, rubin, cindex, db, silhouette, duda, pseudot2, beale, ratkowsky, ball, ptbiserial, frey, mcclain, dunn, hubert, sdindex, dindex, sdbw). The majority rule selects the k value best clustering solution the largest number of clustering indices. Once the optimal number of clusters was identified thanks to the majority rule, a non-hierarchical K-means cluster analysis was computed (iter max = 250, nstart = 50). Obtained clusters were then retrieved and compared according to our external correlates. Variables used as external correlates were gaming motives (MOGQ), GD symptoms (IGD-20), and impulsivity traits (UPPS-P). Clusters were also compared in terms of age and the number of hours spent daily on video gaming. These analyses were carried out using R (v4.2.0). The dataset and the code are available on the OSF link provided (https://osf.io/jk94v/).

Our second research objective was approached by using supervised machine learning to identify which GD symptoms constitute robust predictors of harmonious versus obsessive passion for video games. By using unknown data to evaluate the fitted model, supervised machine learning brings more robust results than traditional approaches where the model is fitted and evaluated on the same data. Two models (elastic net regressions) were computed (one for each type of passion), with the various dimension of IGD-20 assessing GD symptoms used as predictors. These analyses were computed using the ElasticNetCV model, which is a cross-validated (n fold = 5, random state = 42, max iter = 2500) elastic net model that finds the best regularization term (L1 ratio) value for the elastic net regression. The aim of the regularization term is to prevent overfitting of the model. This model has been chosen following the flowchart provided by the Scikit-learn Library documentation. We also used a pipeline (a tool that allows you to chain multiple data preprocessing and modeling steps together into a single object) that scales the data (standard scaler) and fits the model. Based on the supervised machine learning principle, one-third of the data (33 %) were set aside to form a test set to ascertain the model's accuracy. Lastly, we retrieved the coefficients, and the permutation importance values for each predictor. Permutation importance (not related to the coefficients) was computed by shuffling the scores of one predictor and observing the impact of this shuffling on the R^2 score. The purpose of this shuffling is to break the potential relationship between the predictor and the outcome variable (here, harmonious or obsessive passion). The more the fitted

model depends on the predictor, the more the shuffling decreases the model's R^2. This procedure was used for all the predictors in separate runs to compute the permutation importance for each of them. The entire process was repeated 250 times to control the potential effect of a specific shuffling, thus we report the mean and the standard deviation of the permutation importance for each predictor. A permutation importance value of zero means that the shuffled variable had no impact on the predictions done by the fitted model. Supervised machine learning analyses were run using Scikit-Learn V1.0 library in Python (Varoquaux et al., 2015).

3. Results

3.1. Cluster generation

Hierarchical clustering suggested to retain three clusters according to the majority rule. The three clusters' profiles were then generated using the non-hierarchical K-means cluster analysis. Cluster one was labelled "*engaged gamers*" (n = 434) characterized by high harmonious passion (Z_{Score} = 0.675) and low obsessive passion (Z_{Score} = -0.201). Cluster two was labelled "*risky gamers*" (n = 100) with grouped gamers being characterized by a combination of elevated obsessive passion (Z_{Score} = 2.251) and moderately high harmonious passion (Z_{Score} = 0.435). Finally, the third cluster was labeled "*casual gamers*" (n = 311) containing those with low harmonious (Z_{Score} = -1.082) and low obsessive passion (Z_{Score} = -0.443) (Fig. 2). These clusters significantly differed in terms of harmonious (X^2 (2) = 565.87, p <.001) and obsessive (X^2 (2) = 224.49, p <.001) passion scores.

3.2. Cluster validity

Because the Shapiro-Wilk and Kolmogorov-Smirnov normality tests showed non-normal distributions across our data, we used non-parametric tests to examine differences between the clusters in terms of the study variables (variables used to create the clusters and external correlates). To this end, a Kruskal-Wallis rank sum test (X^2) and a post-hoc pairwise Wilcoxon rank sum test with Bonferroni correction were conducted and are reported in Table 2 (also, Fig. 3). All clusters differed significantly from each other regarding harmonious passion (X^2 (2) = 565.87, p <.001), obsessive passion (X^2 (2) = 334.49, p <.001), and the IGD-20 subscales (Relapse: X^2 (2) = 117.34, p <.001; Conflict: X^2 (2) = 89.751, p <.001; Withdrawal: X^2 (2) = 103.66, p <.001; Salience: X^2 (2) = 158.17, p <.001; Tolerance: X^2 (2) = 109.19, p <.001; Mood modification: X^2 (2) = 56.974, p <.001). Differences between clusters were also significant for gaming motives. All gamer groups differed on escape/coping (X^2 (2) = 88.997, p <.001), competition (X^2 (2) = 51.951, p <.001), skill development (X^2 (2) = 90.32, p <.001), and fantasy (X^2 (2) = 76.996, p <.001) motives, where the risky gamers group showed the highest scores, and the casual gamers group the lowest. Also, potentially problematic and engaged gamers differed from casual gamers on recreation (X^2 (2) = 95.211, p <.001) and social (X^2 (2) = 56.848, p <.001) motives. There were no other significant group differences in gaming motives. For the impulsivity traits, potentially problematic and casual gamers differed from engaged gamers on urgency (X^2 (2) = 25.761, p <.001) and lack of premeditation (X^2 (2) = 16.221, p <.001), with lower scores for engaged gamers. Engaged and casual gamers differed from risky gamers on lack of perseverance (X^2 (2) = 15.509, p <.001). For the sensation seeking impulsivity trait, only engaged and risky gamers differed significantly (p <.001). No other significant differences were observed regarding impulsivity traits. There were no differences between clusters in age (X^2 (2) = 5.41, p = .067). Finally, the number of hours of gaming per day was lower in casual gamers (Mdn = 1) than in both the engaged (Mdn = 2, p <.001) and risky gamers (Mdn = 2, p <.001), with no difference between the latter two (p = .21).

3.3. Supervised machine learning analysis (elastic net regression models)

Two models were computed to identify which types of GD symptoms (measured by the IGD-20) predicted either harmonious or obsessive passion for gaming (see Table 3, for details). Both elastic net regression models were trained using a train sample composed of 566 participants and tested on a test sample of 279 participants (33 % of the dataset).

The first model aimed to predict the harmonious passion level (R^2 = 0.192). The salience dimension showed the highest positive coefficient (β = 2.91), followed by mood modification (β = 1.86), tolerance (β = 1.59), and relapse (β = 0.35). The conflict dimension showed a high but negative coefficient (β) of −3.35. A negative coefficient was also found for the withdrawal dimension (β = -0.10). When examining permutation importance (PI), the conflict (PI = 0.22) and salience (PI = 0.18) dimensions were associated with the largest reduction in R^2 when their scores were shuffled.

The second model aimed to predict the obsessive passion level (R^2 = 0.190). Four GD symptoms were found to contribute almost equally to explaining obsessive passion for gaming. These include withdrawal (β = 1.04), conflict (β = 1.03), salience (β = 1.00), and relapse (β = 0.91). The tolerance (β = 0.70) and mood modification (β = 0.47) dimensions obtained the lowest coefficients. Regarding permutation importance,

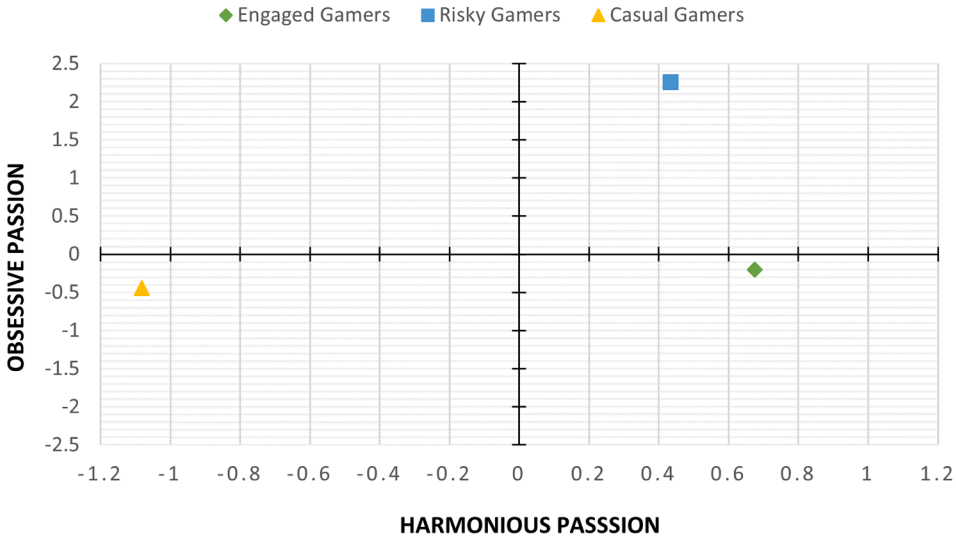

Fig. 2. Clusters generation using harmonious and obsessive passion (Z-scores).

Table 2
Clusters means and differences on age, daily hours of gaming, IGD-20, UPPS-P, and MOGQ (N = 845).

Scale	Factor	Range	Dataset Mean (SD)	Engaged Gamers (n = 434)		Risky Gamers (n = 100)		Casual Gamers (n = 311)		Kruskal-Wallis test		
				Z-score (SD)	Median	Z-score (SD)	Median	Z-score (SD)	Median	X^2	df	p
Passion	Obsessive	6–42	10.89 (7.17)	−0.2 (0.48)	9[b**, c**]	2.25 (1.03)	24.5[c**]	−0.44 (0.43)	6	334.49	2	<0.001
	Harmonious	6 – 42	23.93 (9.77)	0.67 (0.52)	30[b*, c**]	0.43 (0.79)	30[c**]	−1.08 (0.53)	13	565.87	2	<0.001
IGD-20	Relapse	3 – 15	5.05 (2.47)	−0.03 (0.88)	4[b**, c**]	1.11 (1.27)	8[c**]	−0.31 (0.79)	3	117.34	2	< 0.001
	Conflict	5 – 24	8.63 (3.35)	−0.22 (0.8)	7[b**, c*]	1.04 (1.26)	12[c**]	−0.02 (0.94)	9	89.751	2	<0.001
	Withdrawal	3 – 15	4.39 (1.99)	−0.06 (0.84)	4[b**, c**]	1.08 (1.43)	6[c**]	−0.26 (0.79)	3	103.66	2	<0.001
	Salience	3 – 15	5.7 (2.57)	0.08 (0.85)	6[b**, c**]	1.02 (1.24)	8.5[c**]	−0.44 (0.82)	4	158.17	2	<0.001
	Tolerance	3 – 15	5.3 (2.33)	0.03 (0.89)	5[b**, c**]	0.96 (1.27)	7[c**]	−0.35 (0.82)	4	109.19	2	<0.001
	Mood modification	3 – 15	7.69 (2.91)	0.1 (0.99)	8[b*, c**]	0.55 (1.12)	9[c**]	−0.32 (0.86)	7	56.974	2	<0.001
	Total score	20 – 90	36.76 (11.86)	−0.03 (0.78)	36[b*, c**]	1.25 (1.27)	52.5[c**]	−0.36 (0.85)	29	144.46	2	< 0.001
MOGQ	Escape / coping	7 – 35	17.31 (7.41)	0.15 (0.96)	18[b*, c**]	0.56 (1.11)	22.5[c**]	−0.4 (0.87)	13	88.997	2	< 0.001
	Competition	4 – 20	9.55 (4.25)	0.06 (1)	9[b**, c**]	0.57 (1.07)	11[c**]	−0.27 (0.89)	8	51.951	2	< 0.001
	Recreation	3 – 15	11.66 (3.2)	0.27 (0.89)	13[c**]	0.12 (0.86)	12[c**]	−0.42 (1.05)	11	95.211	2	< 0.001
	Skill	4 – 20	9.53 (4.66)	0.15 (1.02)	10[b**, c**]	0.58 (1.01)	12[c**]	−0.4 (0.8)	7	90.32	2	< 0.001
	Social	3 – 15	5.7 (2.84)	0.14 (1.05)	5[c**]	0.38 (1.12)	6[c**]	−0.31 (0.78)	4	56.848	2	< 0.001
	Fantasy	3 – 15	5.37 (3.09)	0.07 (1.01)	4[b**, c**]	0.67 (1.21)	7[c**]	−0.31 (0.76)	3	76.996	2	< 0.001
	General motivation	24 – 110	59.12 (18.55)	0.19 (0.92)	63[b**, c**]	0.69 (1.1)	77[c**]	−0.49 (0.84)	47	137.46	2	< 0.001
UPPS-P	Urgency	8 – 32	18.63 (4.95)	−0.17 (0.94)	18[b**, c**]	0.28 (0.91)	20	0.14 (1.06)	19	25.761	2	<0.001
	Lack of perseverance	4 – 16	7.49 (2.64)	−0.04 (1)	7[b**]	0.37 (1.07)	9[c**]	−0.06 (0.96)	7	15.509	2	<0.001
	Lack of premeditation	4 – 16	7.13 (2.36)	−0.12 (0.99)	7[b*, c**]	0.15 (0.98)	7	0.12 (1)	7	16.221	2	<0.001
	Sensation seeking	4 – 16	9.96 (3.02)	−0.07 (0.98)	10[b**]	0.25 (0.96)	11	0.02 (1.03)	10	9.7982	2	<0.05 (=0.0075)
Age		18 – 50	23.51 (5.03)	0.04 (0.98)	23	0 (0.94)	22	−0.06 (1.05)	22	5.41	2	0.067
Daily hours		0 – 16	2.02 (1.79)	0.16 (1.02)	2[c**]	0.48 (1.45)	2[c**]	−0.38 (0.59)	1	114.51	2	< 0.001

Note. IGD-20 = Internet Gaming Disorder Test; MOGQ = Motives for Online Gaming Questionnaire; UPPS-P = Urgency (negative), Premeditation (lack of), Perseverance (lack of), Sensation seeking, Urgency (positive), Impulsive Behavior Scale. Wilcoxon rank sum test (p-value adjustment method: Bonferroni): b = Different from cluster 2; c = Different from cluster 3; * = Significant at $p < .05$; ** Significant at $p < .001$.

the conflict (PI = 0.03) and relapse (PI = 0.02) dimensions were related to the largest reduction in R^2 when their scores were shuffled.

4. Discussion

This study aimed to identify different profiles of gamers based on passion types, but also to determine which GD-related symptoms and constructs predict either harmonious or obsessive passion. Three distinct clusters of gamers were identified based on their passion profiles, including risky gamers, engaged gamers, and casual gamers. Supervised machine-learning algorithms identified specific GD symptoms (salience, mood modification, tolerance, low level of conflict) to predominantly predict harmonious passion, whereas a different subset of them (withdrawal, high level of conflict, relapse) were more strongly related to obsessive passion.

4.1. Cluster analysis (person centered approach)

Risky gamers comprised 12 % of our final sample and were characterized by a combination of high levels of obsessive passion and moderately high harmonious passion. Previous research using a variable-centered approach found, on the one hand, that obsessive passion is linked to excessive gaming and negative consequences (Bertran & Chamarro, 2016; Lafrenière et al., 2009); on the other hand, harmonious passion was found to potentially protect from such negative consequences (Bertran & Chamarro, 2016). Our study, which endorses a person-centered approach shows for a subgroup of gamers, that obsessive features overcome harmonious features and promote problematic and uncontrolled engagement in gaming (as reflected by higher GD symptoms) despite the presence of moderately high harmonious passion. In terms of gaming motives, risky gamers showed higher levels of escape/coping, competition, skill development, and fantasy motivations than the other groups, but also a highest general motivation towards gaming. This is in line with previous variable-centered research, which found that obsessive passion is associated with motives such as fantasy, escape, competition, and coping (Orosz et al., 2018). It is worth noting that such gaming motives have also been related to problematic gaming (Ballabio et al., 2017; Bányai et al., 2019; Biolcati et al., 2021; Columb

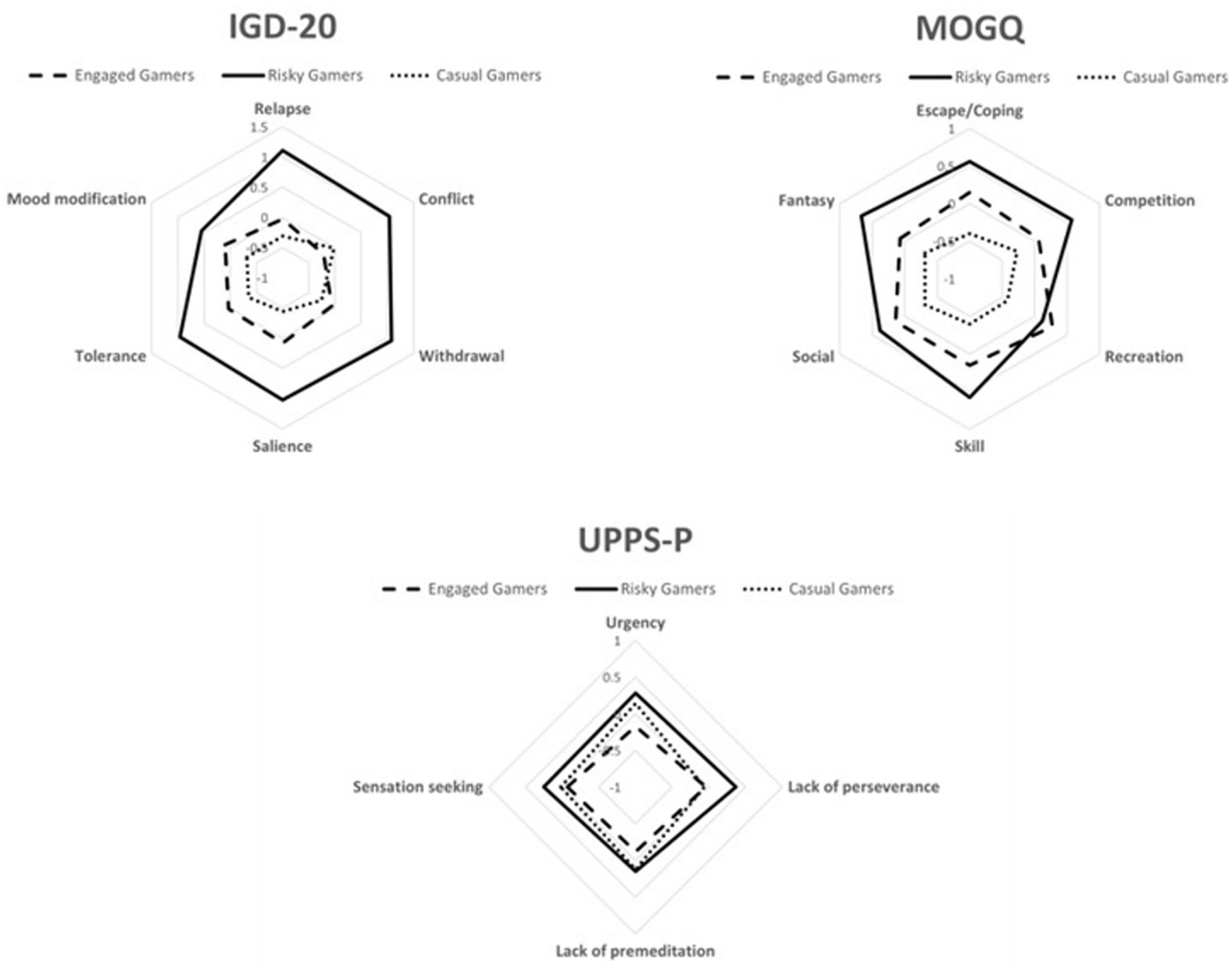

Fig. 3. *Clusters* profiles *on IGD-20, UPPS-P, and MOGQ (Z-scores). Note.* IGD-20 = Internet Gaming Disorder Test; MOGQ = Motives for Online Gaming Questionnaire; UPPS-P = Urgency (negative), Premeditation (lack of), Perseverance (lack of), Sensation seeking, Urgency (positive), Impulsive Behavior Scale.

Table 3
Cross-Validated (5 folds) elastic net regression analyses (supervised machine learning).

Predictors	Harmonious passion (R^2 = 0.192)		Obsessive passion (R^2 = 0.190)	
	Coeff	Permutation Importance (SD)	Coeff	Permutation Importance (SD)
Salience	2.913	0.180 (0.032)	1.000	0.009 (0.013)
Mood modification	1.858	0.077 (0.024)	0.470	−0.002 (0.007)
Tolerance	1.585	0.044 (0.018)	0.703	−0.001 (0.009)
Withdrawal	−0.102	0.000 (0.001)	1.039	0.012 (0.015)
Conflict	−3.350	0.219 (0.039)	1.028	0.028 (0.014)
Relapse	0.352	0.005 (0.004)	0.913	0.021 (0.013)

et al., 2023; Laconi et al., 2017; Melodia et al., 2022; Moudiab & Spada, 2019; Rafiemanesh et al., 2022; Šporčić & Glavak-Tkalić, 2018; Wu et al., 2017). In terms of impulsivity traits, we found that risky gamers are especially characterized by a lack of perseverance, which is defined as the "*difficulty to remain focused on potentially boring and/or demanding tasks*", and is closely linked to the conscientiousness trait of the Big Five model of personality (Whiteside & Lynam, 2001). This result is consistent with the results of a previous variable-centered study, which reported a positive relationship between the lack of perseverance dimension of impulsivity and obsessive passion (Orosz et al. 2016). Yet, and more interestingly, our results echo previous person-centered research results, which identified a group of "unregulated escapers" characterized by elevated lack of perseverance and coping motives (Billieux, Thorens, et al., 2015), or a group of "escapers" characterized by low conscientiousness and coping motives (Larrieu et al., 2022). It is worth noting that while urgency is particularly relevant in substance use disorders (Hildebrandt et al., 2021), this impulsivity trait did not differ between potentially problematic and casual gamers in our study. Risky gamers seem to display a combination of dysfunctional traits and motivational profile, calling for individualized treatment approaches aiming at reducing impulsivity and implementing more adaptive coping and/or emotion regulation strategies. Such interventions could help these gamers to reduce their obsessive gaming involvement and help them gaming in a way that is integrated into their daily life instead of interfering with it.

Engaged gamers comprised more than half of the participants (51 %). They are characterized by a very high level of harmonious passion and a low level of obsessive passion. This cluster was named after the seminal work of Charlton and Danforth (2007) suggesting the need to discriminate between two types of intensive involvement in gaming, namely high but non-problematic engagement versus high and dysfunctional engagement. Crucially, despite not being different from risky gamers in terms of reported time spent gaming, they showed the lowest level of conflict (i.e., gaming-related negative consequences), providing further evidence to Vallerand's notion that harmonious passions are well integrated into one's life, allowing for needs to be fulfilled without

interfering with important areas of functioning (e.g., social, professional). Our results are also in line with previous studies showing that gaming time (or screen time) is not a good indicator of problematic gaming (Billieux et al., 2013; Charlton & Danforth, 2007; Király, Tóth, Urbán, Demetrovics, & Maraz, 2017; Demetrovics & Király, 2016). Engaged gamers present a balanced motivational background, with the highest level of recreational motives and low to medium impulsivity. They are also characterized by the lowest scores in urgency and lack of premeditation, and report higher perseverance than the potentially problematic gamer group, which probably contributes to their regulated and non-problematic involvement in gaming.

The casual gamer group corresponds to 37 % of the sample. These gamers are characterized by a low level of both harmonious and obsessive passions. They show lower involvement in video games (e.g., self-reported lower time spent gaming) and fewer GD symptoms than the other two groups. An analysis of their gaming motives also revealed that - in general - they report less pronounced gaming motives, whatever their type. This profile aligns well with the recreational gamers subtype identified previously by Billieux, Thorens, et al. (2015) and Larrieu et al. (2022). In fact, it is likely that these gamers fulfill their basic needs through non-gaming activities and thus cannot be considered as passionate gamers in the sense of Vallerand (2010; 2015). In terms of impulsivity, they are generally more impulsive than engaged gamers but less impulsive than problematic ones. Given this profile, it is worth noting that it cannot be excluded that the most impulsive members of this group would display deregulated involvement in other rewarding activities not assessed in the present study. Some studies have highlighted the positive impact that video games can have, thanks to some aspects of the game such as socializing, and on well-being and mental health if they are practiced in a balanced way (Barr & Copeland-Stewart, 2021; Giardina et al., 2021; Halbrook et al., 2019). It is conceivable that casual gamers do not benefit from these positive effects, while engaged gamers do.

4.2. Supervised machine learning analyses (variable centered approach)

The second objective of the study aimed to identify the GD symptoms predicting either harmonious or obsessive passion. The supervised machine learning analyses conducted revealed some important findings, which align well with previous findings from the gaming literature. Regarding harmonious passion, the trained model showed a strong and negative relationship with conflict and positive relationships with salience, mood modification, and tolerance. In contrast, for obsessive passion, the trained model showed positive associations with conflict, relapse, and withdrawal. Taken together, these results are well aligned with previous research showing that substance use disorder criteria, when applied to gaming, mix "central" features indicative of a problem (i.e., conflict, relapse, withdrawal) and "peripheral" features, which rather reflect non necessary problematic involvement (i.e., salience, tolerance, mood modification) (Billieux et al., 2019; Brunborg et al., 2013; Charlton & Danforth, 2007; Deleuze et al., 2018). Interestingly, these results also align well with a recent international Delphi consensus study about the clinical validity, clinical utility, and prognosis value of GD diagnostic criteria included in the DSM-5 and ICD-11 (Castro-Calvo et al., 2021). In detail, the expert panel recruited in this Delphi study agreed that criteria such as tolerance or mood modification, which were more related to harmonious passion in the present study, are not clinically useful as they cannot discriminate between problematic and non-problematic gaming patterns. In contrast, the DSM-5 or ICD-11 criteria such as loss of control (reflected by the relapse items in the IGD-20) or continued use despite negative consequences (reflected by the conflict items in the IGD-20) were judged by the Delphi panel as clinically useful and able to identify pathological gaming patterns, thus aligning with our results regarding obsessive passion. Moreover, it is interesting to note that this pattern is almost identical with the very definition of compulsivity (Muela et al., 2022). Thus, our results are also in line with the work of Muela et al. (2022) who operationalize compulsivity as the main factor driving dysregulated or excessive behavior.

Overall, our pattern of results further suggests that recycling substance use disorder or gambling criteria, in the context of gaming behavior, is susceptible to conflate problematic and non-problematic usage and thus pathologize non-problematic behavior (Billieux et al., 2019; Kardefelt-Winther et al., 2017).

4.3. Limitations

This study has several limitations. First, the cross-sectional nature of the study does not allow for causality assumptions. Further longitudinal studies would bring more insight into the dynamic regarding passions, motivations, and impulsivity traits. Longitudinal studies are also required to determine whether the clusters identified are stable over time. Second, we used self-reported measures that can be influenced by response bias (Dunning et al., 2004). Third, while 21.18 % of our sample reported being offline gamers, one of the scales used in this study refers to online gaming motives (MOGQ). Although some motives might be perceived as less relevant for offline gaming (e.g., social or competition motives), most remain relevant in the context of online gaming (e.g., escape/coping, recreation, skill development, or fantasy motives). It is worth noting that the MOGQ was not used to create the clusters, and only served as an external correlate to compare clusters. Fourth, our sample is composed of a majority of highly educated participants. Nevertheless, the sample size (N = 845) and the fact that we had a very good balance with regards to gender can be considered as a clear strength of this study. Finally, even if we were able to identify several key risk factors for GD in the present study, other factors such as self-esteem (Billieux, Thorens, et al., 2015), childhood trauma (Shi et al., 2020), or mood disturbance (Ostinelli et al., 2021) could also have been considered.

4.4. Conclusion

By combining person-centered and variable-centered approaches, the present study contributes to models of and clinical approaches to the treatment of GD. Regarding the theoretical models, our results emphasize the importance of considering not only symptomatic or diagnostic features, but also underlying psychological processes and mechanisms (Brand et al., 2020). The present results also further emphasize the risk of "recycling" substance use disorder criteria to assess and diagnose GD (Castro-Calvo et al., 2021; Kardefelt-Winther et al., 2017) and potentially other types of excessive behaviors (Billieux et al., 2022; Flayelle et al., 2022). On the clinical aspect, our results support the relevance of person-centered approaches to the treatment of problematic gaming (Billieux, Schimmenti, et al., 2015; Park et al., 2021). Further research should thus be conducted to investigate how process-based and person-centered treatment approaches could be developed and validated to address problem gaming issues. Indeed, it remains an empirical question under which circumstances obsessive involvement in video games changes to a harmonious one, and whether psychological interventions can facilitate this transition, assuming a "controlled use" paradigm rather than an "abstinence-based" paradigm.

CRediT authorship contribution statement

Alexandre Infanti: Writing – original draft, Writing – review & editing. **Carlos Valls-Serrano:** Methodology, Writing – original draft. **José C. Perales:** Methodology, Supervision. **Claus Vögele:** Supervision. **Joël Billieux:** Writing – original draft, Supervision.

Declaration of Competing Interest

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financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data and code are shared on OSF (https://osf.io/jk94v/).

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