Raybould and Tunney *BMC Psychiatry* (2024) 24:652
https://doi.org/10.1186/s12888-024-06072-9

BMC Psychiatry

RESEARCH Open Access

Factor analysis of impulsivity in gaming disorder and internet gaming disorder

Jodie N. Raybould[1,2] and Richard J. Tunney[1*]

Abstract

Background Research suggests that a two-factor model of impulsivity predicts Substance Use Disorder and Gambling Disorder. We aimed to determine whether a similar factor structure was present for Gaming Disorder (GD) and Internet Gaming Disorder (IGD).

Methods Secondary data analysis was conducted on survey responses from 372 participants who had completed a series of questions on facets of impulsivity and their involvement in gaming. Participants were sampled from gaming forums and an online recruitment website. Exploratory factor analysis was conducted on the measures of trait impulsivity, and the identified factors were then analyzed against measures of Gaming Disorder and Internet Gaming Disorder. A confirmatory factor analysis was then run to confirm the model.

Results The exploratory results suggested a five-factor model of impulsivity, with gaming being related to all five factors. Interestingly, only two of those factors (*Urgency* (Positive Urgency, Negative Urgency, Delay Discounting) and *(Impaired) Inhibitory Control* (False Button Presses on Go/No-Go Tasks)) predicted symptom counts above the clinical cut-off for IGD. In addition, *Urgency* was related to symptom counts above 7/9 criteria for IGD, as well as symptom counts above the suggested clinical cut-off for GD. The confirmatory factor analysis suggested that this two-factor model of impulsivity had 'good fit.'

Conclusions This two-factor model of impulsivity is similar to those found in established addiction disorders, in that one factor appears to predict more problematic involvement than the other. However, the results indicate that *Urgency* predicts higher symptom counts than *(Impaired) Inhibitory Control*. This contrasts with previous findings on substance use and gambling, where *(Impaired) Inhibitory Control* was the factor predicting problematic use. However, there was evidence to suggest that gaming is similar to alcohol consumption, where socially acceptable, "healthy," use is related to impulsivity at some level, but *Urgency* is key in the transition from recreational to disordered behavior.

Keywords Gaming, Internet gaming disorder, Gaming disorder, DSM-5, ICD-11, Impulsivity, Addiction, Factor analysis

*Correspondence:
Richard J. Tunney
r.tunney@aston.ac.uk
[1]School of Psychology, Aston University, Birmingham, UK
[2]School of Psychological, Social and Behavioural Sciences, Coventry University, Coventry, UK

Introduction

The World Health Organization's International Classification of Diseases (ICD-11) [1] recognises Gaming Disorder (GD) alongside Gambling Disorder as a form of addiction under the category of 'Disorders due to substance use or addictive behaviours'. By contrast the Diagnostic and Statistical Manual Disorder from the American Psychiatric Association (DSM-5) [2] lists the near synonymous condition Internet Gaming Disorder (IGD) as a condition for further study, but separate to other addictions. Despite targeting the same behaviour, these two conditions present slightly different symptom criteria. The nine IGD criteria are based on substance use disorder and include items such as withdrawal symptoms when gaming is not possible and inability to reduce or stop playing. In contrast, there are only four criteria for GD in the ICD-11, including impaired control over gaming behavior and continued gaming despite negative consequences. We aim to determine if IGD shares similar properties to other addictions and should therefore be listed in future editions of the DSM alongside them, and also confirm whether the ICD-11 placement of GD is correct. Specifically, we examine the role of impulsivity as a predictive factor in engagement with addictive behaviours, and as a risk factor in the transition from recreational to disordered behaviour. The connection between addiction and impulsivity is well established [3, 4]. In this paper, we ask if the factor structure of impulsivity implicated in substance addictions and Gambling Disorder is also associated with Gaming Disorder and Internet Gaming Disorder, as this could more substantially highlight similarities between gaming and formally established addiction sources.

Impulsivity is a stable individual difference composed of several distinct factors, but which collectively can be thought of as a personality trait. There is growing agreement on the multifaceted nature of impulsivity, but debate continues on the exact number of facets and which of these are relevant in explaining addiction. In their study, Dawe et al. [5], argued in favour of a two-factor approach to impulsivity in addiction. Their model consists of *Heightened Sensitivity* and *Rash Impulsivity* to explain substance addiction specifically. In contrast to this addiction model, Whiteside and Lynam [6] proposed a four-factor model for impulsivity in a general population, which was later extended to five factors and used to develop the Urgency, Premeditation, Perseverance, Sensation Seeking, and Positive Urgency Impulsive Behaviour Scale (UPPS-P). If gaming is found to share a similar model of impulsivity to that of other addictions, rather than a general population, then this would lend evidence to the listing of Internet Gaming Disorder alongside Gambling Disorder in future editions of the DSM and inform the researchers and practitioners about potential risk factors for developing a gaming addiction.

Gullo et al. [7], found a *Reward Drive* factor that reflected sensitivity to rewarding stimuli, leading individuals to approach a substance and a *Rash Impulsiveness* factor that reflected an inability to inhibit this approach. In their review of the substance addiction literature, Gullo et al. [8] argued in favor of theoretically driven, bottom-up models that proposed two factors, that in their view delivered the optimal balance between explanatory power, parsimony, and evidence. They discussed the emerging consensus that impulsive drug use involves two fundamental processes and described these as *Approach Impulse* (heightened propensity to approach drugs) and *(Impaired) Inhibitory Control* (reduced capacity to inhibit this approach). They summarize several studies that highlight a considerable overlap between different theoretical models and these two processes. They note that factors such as *Reward Sensitivity* [9], *Delay Discounting* [10], *Sensation Seeking* [11, 12], and *Appetitive Motivation* [9] overlap within *Approach Impulse*, while *Rash Impulsivity* [9], *Motor (Dis)inhibition* [10], *Impulsivity* [11, 12], and *Poor Self-Regulation* [13] overlap within *(Impaired) Inhibitory Control*. Further to this, several studies that they cite support the concept that two impulsivity factors provide a distinct contribution to substance use. For example, several studies highlighted *Sensation Seeking* as predictive of alcohol use and *(Dis)inhibition* as predictive of more problematic substance use [14, 15], while some found that *Reward Sensitivity* was associated with earlier age of substance use and positive drinking expectancies, while *Rash Impulsiveness* was associated with high-risk substance use [9]. Other researchers have described two broadly defined components of impulsivity in substance addiction as *Impulsive Action* (failure to inhibit an inappropriate response) and *Impulsive Choice* (preference for small immediate rewards over larger delayed rewards) [16–18].

Grant and Chamberlain [19] extended this two-factor model to behavioral addictions. They found that the research was mostly focused on *Impulsive Action*, and this was elevated in participants highly involved in the measured behaviors, suggesting a similarity between substance use disorders and behavioral addictions. Hodgins and Holub [20] also described a two-factor model of impulsivity in gambling. They found a *General Impulsivity* factor characterized by self-reported impulsivity [21–23] and ADHD symptoms [24], and a *Sensation Seeking* factor characterized by self-reported sensation-seeking [22, 23] and a Continuous Performance Task (CPT) [25] that measured attention. Gullo et al. [8] suggested that *Sensation Seeking* overlaps with other factors under the heading *Approach Impulse*, however, the CPT is a measure of motor response inhibition and would therefore

align more closely with their *Inhibitory Control* factor. Although aspects of ADHD are related to *Inhibitory Control* [26] and could suggest an overlap between this factor and *General Impulsivity*, this discrepancy in the loading of CPT could suggest a key difference between substance use and gambling addiction in terms of which impulsivity factors are important.

Interestingly, Hodgins and Holub found that *General Impulsivity* correlated with the severity of Gambling Disorder symptoms, while *Sensation Seeking* was related to involvement in general gambling activities. Along with the findings cited by Gullo et al. this could suggest that, despite differences in the specific factors involved, some aspects of impulsivity are related to potentially unproblematic interest in both substances and gambling, while other factors predict problematic involvement or addiction. Specifically, factors that involve *Motor (dis)Inhibition* or *(Impaired) Inhibitory Control* appear to predict problematic levels of behavior. This finding also reflects previous work by Hodgins et al. [27] that suggests a model of Gambling Disorder where different factors of impulsivity predict high levels of activity compared to those that predict actual addiction. This could indicate a specific grouping of impulsivity facets, led by *(Impaired) Inhibitory Control*, that are related to the transition from unproblematic to problematic behavior.

In an earlier study [28] we sought to determine which aspects of impulsivity could predict involvement in gaming and in the transition from recreational use, to problem use. To do so we administered questionnaires based on the ICD-11 [1] and DSM-5 [2] criteria for Gaming Disorder and Internet Gaming Disorder to gamers recruited online. We measured impulsivity using two trait measures of impulsivity (BIS-11 and UPPS-P) [6, 21], the Monetary Choice Questionnaire of delay discounting [29], and the Go/No-Go task as a measure of inhibitory control [30], which are all factors of impulsivity that have been associated with addictive behaviors. The Go/No-Go task differs from the other measures in that it is a speeded reaction time task that measures inhibitory control as the ability to respond to a go-signal and inhibit a response when a stop-signal is presented [31]. Inhibitory control measured using the Go/No-Go task is associated with a range of addictive behaviors including gaming [28, 30, 32–34]. The results indicated that different aspects of impulsivity were related to the whole sample compared to those that related specifically to participants scoring above the suggested symptom thresholds. Here we aim to test whether video gaming relates to impulsivity in a similar two-factor model, where one factor relates to gaming as an activity while the other specifically relates to potentially disordered behavior.

In this study we conduct exploratory and confirmatory factor analysis on the data from this previous research [28]. The aim of the study was to determine whether gaming follows a similar two-factor model of impulsivity to the previous findings discussed [8, 19, 20]. We therefore hypothesize that a two-factor model of impulsivity will be found for gaming, lending weight to the argument that gaming is addictive and should be listed as an addiction alongside Gambling Disorder in the DSM. Specifically, we predict that an impaired inhibitory control factor will predict problematic use of video games, while the second factor (consisting of items related to approach, sensation seeking, or delay or gratification) will predict sub-clinical, or "healthy" use. In testing this hypothesis, we aim to find whether gaming shares fundamental similarities to established addiction disorders. This will further our understanding of gaming as a potential addiction.

Materials and methods

Participants

There were 397 participants, with 196 from recruited gaming forums on Reddit and Facebook (r/gamers and RT UK Chat), and 201 recruited using prolific.co. Five participants withdrew during the survey and 20 failed attention check questions, leaving a total of 372 participants who completed the survey and 328 who additionally completed the Go/No-Go tasks. One-hundred and eighty-three of the sample identified as male, 184 as female, and 5 as neither. The mean age was 26.23 years (SD=6.843).

Materials

Subjective socioeconomic status was measured using the MacArthur Subjective Social Status scale [35]. This measures subjective status by asking participants to place themselves on a ladder where the highest rung (labelled 10) represents the most affluent individuals. Impulsivity was measured using the Barratt Impulsivity Scale (BIS-11; α=0.82) [21], the Urgency, Premeditation, Perseverance, Sensation Seeking and Positive Urgency Impulsive Behaviour Scale (UPPS-P; α=0.75) [6], the Monetary Choice Questionnaire (27-MCQ; α=0.88) [36], and a hot and cold Go/No-Go task. The BIS-11 and UPPS-P scales are self-report measures of multiple impulsivity factors, while the 27-MCQ measures delay discounting by asking participants whether they would prefer a smaller or larger amount of money, with the larger sum being given at a later date. The hot and cold Go/No-Go task involves participants pressing the space bar of their keyboard when viewing faces of a specific gender (cold) or emotion (hot) and withholding a button press in response to the opposite gender (female: go, male: no-go) or emotion (happy: go, angry: no-go). Faces for the task stimuli were taken from the RADIATE racially diverse face set [37].

Gaming involvement was measured using a question on average hours of play within a week, and potential

problematic involvement in gaming was measured using self-reported measures based on the diagnostic criteria for Internet Gaming Disorder (IGD; KR20=0.67) [2] and Gaming Disorder (GD; KR20=0.67) [1]. The IGD measure consists of the nine DSM-5 symptom criteria presented as yes/no questions. The items were scored as 0 for no and 1 for yes, giving a total maximum possible score of nine symptom criteria present. We used the recommended clinical cut-off of 5/9 symptoms to identify risk of potential diagnosis. Participants were asked to indicate if they had experienced these symptoms within the last year. The GD measure included the four ICD-11 symptom criteria presented as yes/no questions. Items were scored as 0 for no and 1 for yes, resulting in a maximum possible score of four symptoms present. We used the recommended clinical cut-off of 3/4 symptoms to identify risk of potential diagnosis.

Procedure

The data were collected online using Qualtrics and Pavlovia. After providing their consent the participants completed the BIS-11, UPPS-P and then 27-MCQ measures of impulsivity. A simple attention check was then administered before participants provided their average hours of gameplay per week and answered the IGD and GD dichotomous scales. At the end of the survey participants were redirected to Pavlovia, where they were asked to complete the hot and cold Go/No-Go tasks to measure inhibitory control. Image order was randomized for both tasks, with 60 "Go" (button press) and 20 "No-Go" (no button press) occurrences per run. Cues were shown for 2 s, or until a button was pressed.

Statistical analysis

Analysis was conducted in RStudio Version 2023.12.1+402 while running R version 4.3.0 [38] using the built-in stats and lavaan [39] packages. We used Kaiser-Meyer-Olkin sampling accuracy and Bartlett's Test of Sphericity to confirm the suitability of the data for factor analysis. In the exploratory analysis, high factor loadings were defined as data above 0.3 or below −0.3 in value. We included the second order factors of the BIS-11, five UPPS-P factors, proportion score for the 27-MCQ, and commission errors on the hot and cold Go/No-Go tasks in the analysis. After appropriate labels were assigned to each factor these were analyzed against demographic and gaming measures using Pearson's bivariate correlation. We then aimed to determine whether particular factors predict potential addiction using logistic regression on suggested clinical and conservative cut-off points from research and the diagnostic materials. The identified factors were then tested in a confirmatory factor analysis, using maximum likelihood as the estimator.

Results

Preliminary analysis

Due to missing values in the Go/No-Go analysis was conducted on $n=247$ datapoints. A Kaiser-Meyer-Olkin sampling accuracy score of 0.81 and Bartlett's Test of Sphericity ($\chi^2_{91}=1085.673$, $p<.001$) indicated good factorability of the variables. Principal Axis Factoring was used, and the PCA yielded five Eigenvalues greater than one, accounting for 68.72% of the variance. Mean item complexity was 1.6, with acceptable root mean square of the residuals (RMSR=0.07). Table 1 shows the factor loadings and communalities after a direct oblimin rotation, with Eigenvalues given in parentheses. Oblimin rotation was chosen because this allows for correlation between the latent factors while Varimax does not. The dataset being analyzed represents factors of impulsivity that are likely to be correlated.

Table 1 Rotated factor loadings from analysis of trait impulsivity factors with eigenvalues in parentheses

	1 (3.01)	2 (1.85)	3 (1.79)	4 (1.70)	5 (1.22)
UPPS-P (Lack of) Premeditation	0.842*	−0.101	−0.023	0.060	0.184
BIS-11 Self-Control	0.737*	0.235	−0.065	0.012	0.015
UPPS-P (Lack of) Perseverance	0.679*	−0.197	0.154	0.102	−0.129
BIS-11 Perseverance	0.656*	−0.009	0.146	0.036	0.034
BIS-11 Cognitive Complexity	0.551*	0.334	−0.047	−0.228	−0.409
BIS-11 Motor	0.425*	0.209	0.078	0.237	0.312
27-MCQ Proportion Sooner	−0.051	0.789*	−0.018	−0.111	0.078
UPPS-P Negative Urgency	−0.105	0.715*	0.058	0.295	−0.064
UPPS-P Positive Urgency	0.221	0.668*	0.152	0.000	0.163
Hot False Presses	−0.050	0.050	0.919*	−0.048	−0.052
Cold False Presses	0.063	0.011	0.879*	−0.004	0.026
BIS-11 Cognitive Instability	−0.031	−0.026	0.017	0.901*	0.010
BIS-11 Attention	0.352	0.196	−0.065	0.655*	−0.128
UPPS-P Sensation Seeking	0.077	0.125	−0.041	−0.085	0.903*

Notes: Factors presented with (eigenvalues): 1-General Impulsivity; 2-Urgency; 3-(Impaired) Inhibitory Control; 4- (Impaired) Attention; 5-Sensation Seeking. Highly loaded items for each factor are highlighted in grey. High loading refers to any factor over 0.3 or below −0.3; however, where an item loaded on multiple factors only the highest loading was assigned*

Table 2 Correlations between demographic and clinical characteristics of the sample and Factors of Impulsivity

	1	2	3	4	5
Age (246)	−0.093	−0.081	−0.044	−0.169**	−0.132*
MacArthur (247)	0.110	0.189**	0.203**	−0.003	0.143*
DSM-5 Score (247)	0.197**	0.433**	0.131*	0.153*	0.101
ICD-11 Score (247)	0.265**	0.235**	0.173**	0.116	0.135*
Hours Gaming (247)	0.157*	0.325**	0.173**	0.150*	0.068

Notes: Factors: 1-General Impulsivity; 2-Urgency; 3-(Impaired) Inhibitory Control; 4- (Impaired) Attention; 5- Sensation Seeking. Significance is indicated as followed: $p<.001^{***}p<.01^{**}p<.05^{*}$

Table 3 Binary logistic regression of impulsivity factors and gaming measures

DSM-5 Clinical Cut-Off Point (5+)		
$\chi^2_5 = 34.495, R^2 = 0.177, p < .001^{***}$	General Impulsivity	$_{Exp}B = 1.183, SE = 0.209, W = 0.649, p = .421$
	Urgency	$_{Exp}B = 1.983, SE = 0.205, W = 11.198, p < .001^{***}$
	Inhibitory Control	$_{Exp}B = 1.444, SE = 0.167, W = 4.807, p = .028^{*}$
	Attention	$_{Exp}B = 0.982, SE = 0.189, W = 0.009, p = .925$
	Sensation Seeking	$_{Exp}B = 1.134, SE = 0.202, W = 0.389, p = .522$
ICD-11 Cut-Off Point (3+)		
$\chi^2_5 = 17.086, R^2 = 0.100, p = .004^{**}$	General Impulsivity	$_{Exp}B = 1.201, SE = 0.231, W = 0.630, p = .427$
	Urgency	$_{Exp}B = 1.828, SE = 0.213, W = 7.989, p = .005^{**}$
	Inhibitory Control	$_{Exp}B = 1.030, SE = 0.182, W = 0.027, p = .869$
	Attention	$_{Exp}B = 0.934, SE = 0.213, W = 0.103, p = .748$
	Sensation Seeking	$_{Exp}B = 1.292, SE = 0.226, W = 1.286, p = .257$
DSM-5 Conservative Cut-Off Point (7+)		
$\chi^2_5 = 42.229, R^2 = 0.285, p < .001$	General Impulsivity	$_{Exp}B = 1.027, SE = 0.313, W = 0.007, p = .932$
	Urgency	$_{Exp}B = 4.976, SE = 0.310, W = 26.823, p < .001^{***}$
	Inhibitory Control	$_{Exp}B = 1.064, SE = 0.236, W = 0.069, p = .792$
	Attention	$_{Exp}B = 0.936, SE = 0.289, W = 0.053, p = .819$
	Sensation Seeking	$_{Exp}B = 0.929, SE = 0.329, W = 0.050, p = .823$

Notes: Significance is indicated as followed: $p<.001^{***}p<.01^{**}p<.05^{*}$

The first rotated factor, accounting for 32.4% of the variance, had the highest loadings from *motor*, *perseverance*, *self-control*, *cognitive complexity*, *lack of premeditation*, and *lack of perseverance.* The second factor, accounting for 11.24% of the variance, had high loadings from *negative urgency*, *positive urgency*, and *delay discounting*. The third factor, accounting for 9.32% of the variance, had high loadings from false presses on both the hot and cold go/no-go tasks. The fourth factor, accounting for 8.6% of the variance, had high loadings from *attention* and *cognitive instability*. The fifth factor, accounting for 7.18% of the variance, only had high loadings from *sensation-seeking*. We labelled the factors *General Impulsivity* (Factor 1), *Urgency* (Factor 2), *(Impaired) Inhibitory Control* (Factor 3), *(Impaired) Attention* (Factor 4), and *Sensation Seeking* (Factor 5). We then combined items into single factor scores for further analysis.

Relationship to gaming

We next conducted bivariate correlation analysis of the demographic and clinical measures against the identified factors. Results indicated that *(Impaired) Attention* and *Sensation Seeking* were related to lower age, *Sensation Seeking* and *Urgency* were positively correlated with a male gender identity and negatively with a female identity. *Urgency*, *(Impaired) Inhibitory Control*, and *Sensation Seeking* were related to higher perceived social status. In addition, all factors were positively related to at least one measure of gaming, suggesting that higher impulsivity in all areas was related to higher symptom counts or average hours of play (Table 2).

We next used binary logistic regression to determine which of the factors predicted symptom counts above the clinical cutoff points for the DSM-5 (IGD; 5+) and ICD-11 (GD; 3+) measures. We found a significant model for the DSM-5, where *Urgency* and *(Impaired) Inhibitory Control* were related to the clinical cut-off point, while *General Impulsivity*, *(Impaired) Attention*, and *Sensation Seeking* were not. Similarly, we found a significant model for the ICD-11, where *Urgency* was related to the clinical cut-off point, but not *General Impulsivity*, *(Impaired) Inhibitory Control*, *(Impaired) Attention*, nor *Sensation Seeking* (Table 3.)

Considering the different results for both the DSM-5 and ICD-11 measures, we also examined a more conservative cut-off point of seven for the DSM-5, as suggested by Raybould et al. [40]. Similarly to the ICD-11 results, we found a significant model where only *Urgency* was related, while *General Impulsivity*, *(Impaired) Inhibitory Control*, *(Impaired) Attention*, and *Sensation Seeking* were not. This suggests that a more conservative cut-off point for the DSM-5 may lead to both the ICD-11

and DSM-5 identifying a similar group of participants (Table 3.)

Confirmatory factor analysis

Finally, we tested the proposed two-factor model of impulsivity in a confirmatory factor analysis utilizing maximum likelihood estimation. Chi-square returned a non-significant p-value suggesting the model is valid (p=.277), and both the Comparative Fit Index (CFI=0.996) and Tucker-Lewis Index (TLI=0.989) suggested good model fit. This was further confirmed by a root mean square error of approximation below 0.06 (RMSEA=0.033) and a standardized root mean square residual below 0.07 (SRMR=0.033). Together, this suggests that a two-factor model of impulsivity for gaming may be valid.

Discussion

Our findings suggest that only two factors from a five-factor model of impulsivity significantly relate to gaming disorder. CFA then confirmed that this two-factor model of impulsivity was valid, supporting our first hypothesis that a two-factor model would be found. The factors of interest included an *Urgency* factor that appears to reflect the impulse to make choices that offer short-term benefits without considering the long-term consequences, and an *(Impaired) Inhibitory Control* factor that reflects an impaired ability to inhibit or prevent impulsive movement. Although this partially supports our second hypothesis, as we found an inhibitory control factor to be related to gaming, it was the *Urgency* factor that significantly related to the highest scores on measures of gaming addiction, with *(Impaired) Inhibitory Control* predicting sub-clinical use. Despite this, we conclude that Internet Gaming Disorder and Gaming Disorder share similarities with other addictions in having a two-factor impulsivity structure, lending weight to the claim that Internet Gaming Disorder should be listed in future editions of the DSM alongside other addictions and confirming the placement of Gaming Disorder as a form of addiction in the ICD-11.

In an exploratory factor analysis, we initially found a five-factor structure for impulsivity where all five factors were related to recreational gaming. The *General Impulsivity* factor appears to be a general measure of self-reported impulsivity that covers multiple facets from the BIS-11 and UPPS-P. This overlap is not surprising because Whiteside and Lynam [6] made use of the BIS-11 s-order factors in the development of the UPPS-P. In their study both Motor and Non-Planning impulsivity were loaded onto *(Lack of) Premeditation*, and this is reflected here with the relevant BIS-11 and UPPS-P facets loading onto the same factor. Interestingly, while in Whiteside and Lynam's study Attentional impulsivity was loaded onto the *Urgency* factor, here the relevant BIS-11 facets form a separate *(Impaired) Attention* factor instead. This appears to be reflective of the original second-order BIS-11 Attention factor. Despite this, we did identify the *Urgency* and *(Impaired) Inhibitory Control* factors in this study, as well as a *Sensation Seeking* factor that reflects the *Sensation Seeking* factor of the UPPS-P.

It is important to note however, that factor analysis is not an entirely objective method [41], and the results are largely determined by which measures are entered. This has led to a variety of models ranging from 2 to 5 factors of impulsivity emerging in the extant literature [9, 42, 43]. Impulsivity is not explicitly listed as a key feature of addiction in diagnostic materials, but there is evidence of a strong association between impulsivity and addictive syndromes [44, 45]. The key question for this study is therefore not how many factors of impulsivity we find in the exploratory analysis, but instead what number and type of factors in the data are related to potentially problematic gaming, and whether a two-factor model like those observed in previous addiction research is plausible. In finding that only two out of five identified factors significantly related to disordered gaming, a confirmatory factor analysis was conducted that found this two-factor structure to be valid, therefore lending weight to the argument for a two-factor approach.

As previously stated, the factors that related to the clinical cut were *(Impaired) Inhibitory Control*, characterized by false button presses on hot and cold Go/No-Go Tasks, and *Urgency*, characterized by self-reported positive and negative urgency, and delay discounting. *(Impaired) Inhibitory Control* appears to be measuring the extent to which an individual can suppress (or inhibit) an automatic response, such as pressing a button upon viewing a prompt. In comparison, *Urgency* appears to measure an individual's tendency to act quickly or make a more short-term choice based on different stimuli. Positive and negative urgency from the UPPS-P both represent emotion-based stimuli, whereas the 27-MCQ reflects the tendency to select a smaller but sooner reward based on individual willingness to wait, which is affected by the perceived value of the future reward.

This result is similar to the model proposed by Grant and Chamberlain [19], where *Impulsive Action* referred to an inability to inhibit motor responses, while *Impulsive Choice* reflected a preference for smaller immediate rewards. In addition, *Approach Impulse* [8] included aspects reflected by our *Urgency* factor, such as delay discounting, while *(Impaired) Inhibitory Control* from Gullo et al. [8] reflects our *(Impaired) Inhibitory Control* factor. This could lend weight to the argument that gaming is like established addiction in its relationship to impulsivity, potentially supporting the argument that gaming can become addictive. It is important to note that the

General Impulsivity factor found by Hodgins and Holub (2) does not appear to overlap as substantially with these findings, or those on substance use. However, while this might suggest that gaming shares more similarities with substance use than gambling, the symptom criteria that inform measures of IGD and GD are modelled on symptoms of substance use, skewing this conclusion (Table 4.)

In light of differences between the ICD-11 and DSM-5 findings in our study, we elected to test a more conservative cut-off point for IGD and explore the highest levels of potentially problematic gaming [40]. In doing so, we find that only *Urgency* is significant suggesting that *Urgency* may be associated with the highest levels of potentially problematic involvement in gaming. If we assume that the clinical cut-off point suggested in the DSM-5 is clinically relevant, then gaming is different to established addictions, since both significant factors are predicting problematic use, or addiction. However, there is also a similarity, in that *(Impaired) Inhibitory Control* is predicting problematic use. In contrast, if we assume that the cut-off point is too liberal, then the comparison reverses. Instead, we find a similarity in the fact that one factor is predictive of high involvement, while the other may indicate potentially problematic use, and a substantial difference because the factor predicting problematic use is no longer *(Impaired) Inhibitory Control* but is instead *Urgency*.

Despite this, Smith and Cyders [46] noted that traits related to urgency are important in predicting the onset of substance use in children and young adults. Similarly, Stautz and Cooper [47] noted that the literature on alcohol consumption typically finds that although all impulsivity traits are associated with alcohol consumption, both Sensation Seeking and Positive Urgency are the most predictive. They also found that, like gaming, positive, and negative urgency showed the strongest relationships with alcohol consumption. This could indicate that gaming is similar to alcohol consumption, where socially acceptable and mostly healthy levels of consumption are related to impulsivity at some level, but *Urgency* is key in the transition to potentially unhealthy use. In contrast, Ersche et al. [48] found that *(Impaired)* inhibitory control was a hallmark of stimulant addiction. This could indicate substantial differences between gaming and substances in terms of impulsivity. However, caution is needed when aggregating across different brain systems and disorders. Although some similarities have been found between different addictive behaviors and substances, there are clearly important differences. This means that one explanation to define "addiction risk" generally may not be appropriate. Badiani et al. [49] argue that opiate and psychostimulant addiction are both behaviorally and neurobiologically different. While stimulants reliably improve inhibitory control measured through performance on a Stop Signal Task [46], drugs that enhance serotonin may instead impair performance [50, 51]. These differences are important when considering addiction treatment.

It would therefore be useful in future research to explore the differences between this and previous studies in more detail. Firstly, to test whether the findings of this study are replicable, and secondly, to explore potential explanations for the differing relationships. It may be, for example, that the more problematic expressions of gaming relate to *Urgency*, rather than *(Impaired) Inhibitory Control*, because of the fundamentally rewarding aspect of many video games. A player can receive multiple

Table 4 Comparison between two-factor models of Impulsivity in Addiction and Gaming

	Present Study	Gullo et al. (2014)	Hodgins and Holub (2015)	Grant and Chamberlain (2010)
	Gaming	**Substance Use**	**Gambling**	**Behaviour**
Factor One	**Urgency**	**Approach Impulse**	**Sensation Seeking**	**Impulsive Choice**
	Positive Urgency Negative Urgency Delay Discounting	Heightened propensity to approach drugs Overlap with: Sensation Seeking Delay Discounting	ISS – Sensation Seeking I7 – Venturesomeness CPT – Reaction Times CPT – Commissions (Analogous to Inhibitory Control)	Preference for immediate smaller rewards over larger later rewards (Analogous to Delay Discounting)
Factor Two	**(Impaired) Inhibitory Control**	**(Impaired) Inhibitory Control**	**General Impulsivity**	**Impulsive Action**
	False responses on Go/No-Go Tasks	Reduced capacity to inhibit approach Overlap with: Motor (Dis)inhibition	I7 – Impulsiveness BIS-11 Non-Planning ISS – Impulsivity BIS-11 Attention BIS-11 Motor ADHD – Impulsivity ADHD – Hyperactivity	Poor response inhibition

Notes: In all cases but gaming, factor one is predictive of high involvement, while factor two is predictive of potential problematic use/higher symptom counts. In the current study on gaming the reverse trend was found

I7 = Eysenck, ISS = Sensation Seeking Measure

"trophies" or "achievements" for their actions, with some of these not reflecting actual game success. For example, in Deadpool by Activision, The Sly Collection by Sucker Punches, and Double Dragon Neon by WayForward Technologies an achievement is received for simply starting the game. Research into whether the relationship between *Urgency* and problematic gaming exists in genres or specific games that don't offer these consistent rewards could therefore be useful.

Finally, we noted that the DSM-5 scores were consistently related to the same factors as average hours of gameplay. In comparison, the ICD-11 was not related to *Attention* but was related to *Sensation Seeking*, suggesting a difference in the aspects of gaming being measured by the ICD-11 compared to the DSM-5 and frequency of play. This is interesting since both Hodgins and Holub [20] and Gullo, Loxton [9] highlighted *Sensation Seeking* as a key factor in addiction. In addition, the clinical cut-off point for the ICD-11 was only significantly related to *Urgency*, and not *(Impaired) Inhibitory Control*. This could indicate that the ICD-11 measure is useful in identifying gamers at the upper-end of the potential problem-gaming spectrum, as the highest symptom counts on the DSM-5 measure were also only related to *Urgency*. It could therefore be the case that while the current clinical cut-off point of the DSM-5 IGD measure identifies diagnostic orphans and sub-clinical levels of gaming. A more conservative cut-off and the ICD-11 criteria are needed to identify potentially addicted individuals.

Conclusion

We found that only two factors from a five-factor model of impulsivity were significant in disordered gaming. This two-factor model was then supported by confirmatory factor analysis suggesting similarities to the findings reported by Gullo et al. [8] on substance use, Grant and Chamberlain [19] on behavioral addiction, and Hodgins and Holub [20] on Gambling Disorder. These results initially suggest that gaming may be similar to established addiction disorders in its relationship to impulsivity. This two-factor relationship to impulsivity consisted of *(Impaired) Inhibitory Control* (Hot and Cold Go/No-Go Button Presses) and *Urgency* (Positive Urgency, Negative Urgency, and Delay Discounting). However, we noted that *Urgency* was significantly related to the clinical cut-off point for the ICD-11 and the highest scores on the DSM-5 measure. This could indicate that, if gaming can be addictive, *Urgency* predicts potentially problematic gaming while *(Impaired) Inhibitory Control* predicts sub-clinical levels of gaming or high involvement in the activity. Importantly, impulsivity itself is not pathological, but these findings may indicate which impulsive traits are most predictive of IGD and GD. This contrasts with the findings of Gullo et al. [7] and Hodgins and Holub [20], where measures related to *(Impaired) Inhibitory Control* predicted problematic use.

Abbreviations

27	MCQ–The 27–Item Monetary Choice Questionnaire
BIS	11–The 11–Item Barratt Impulsivity Scale
DSM	5–Diagnostic and Statistical Manual of the American Psychiatric Association (5th edition)
GD	Gaming Disorder (as listed in the ICD–11)
ICD	11–The World Health Organization International Classification of Diseases (11th Edition)
IGD	Internet Gaming Disorder (as listed in the DSM–5)
UPPS	P–Urgency, Premeditation, Perseverance, Sensation Seeking, and Positive Urgency Scale

Author contributions

JR contributed to the conceptualization, data curation, data analysis, writing and reviewing of the article. RT contributed to the design and supervision of the research, and contributed to the writing of the manuscript.

Funding

The data collection for this study was funded by Aston University, Birmingham as part of a PhD studentship. Aston University was not involved in the study design, data collection, analysis, or write-up. Ethical approval was granted by the Aston University ethics committee.

Data availability

The datasets generated and/or analysed during the current study are available in the Open Science Framework repository, https://osf.io/er3wg/. The data and materials used for this analysis were part of a pre-registered study at osf.io/mz4wh. The analysis for this study was also pre-registered at https://osf.io/kg6pj.

Declarations

Ethics approval and consent to participate

All participants gave electronic informed consent before taking part in the study. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human subjects were approved by the College of Health and Life Research Science Ethics Committee.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 20 July 2023 / Accepted: 10 September 2024
Published online: 03 October 2024

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