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Pathological gaming: a longitudinal study from the perspectives of mental health problems and social stress model

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ABSTRACT

Debates about pathological gaming continues in the wake of the World Health Organization's (WHO) decision to establish a gaming disorder diagnosis. Questions persist whether gaming disorder is best conceived as a stand-alone psychiatric disorder, or whether it heralds or accompanies other, more established conditions, such as depression or ADHD. We tested these hypotheses in a sample of 3,034 youth from Singapore. Evidence suggests that pathological gaming is a somewhat unstable construct, often remitting spontaneously. Youth with preexisting ADHD or depression were more likely to develop later pathological gaming problems, while the inverse was not true, with neither early pathological gaming nor gaming time predictive of later mental health problems. Results suggest that, whenever there is any need to conduct robust evidence-based studies, more evidence should be collected before new disorders are recognized by means of "expert consensus".

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Video games; pathological gaming; addiction; adolescents; preregistration

In 2018, the WHO announced they would include "gaming disorder" in the International Classification of Diseases (ICD) 11th edition (WHO, 2018). This set off a firestorm of controversy among scholars and the general public. The media psychology and cyberpsychology divisions of the American Psychological Association and Psychological Society of Ireland released a joint statement condemning the WHO decision as unscientific (American Psychological Association Society for Media Psychology & Technology & Psychological Society of Ireland Special Interest Group in Media & the Arts & Cyberpsychology, 2018). Groups of scholars wrote letters both critiquing (e.g., van Rooij et al., 2018) and supporting the WHO decision (e.g., Saunders et al., 2017). The controversy intensified when emails from some WHO administrators were revealed to disclose that political pressure from unspecified Asian countries played some role in the WHO's decision (Bean, Nielsen, van Rooij, & Ferguson, 2017). Surveys of

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scholars reveal divergent opinions in the scholarly field, with some scholars accepting of and other skeptical of gaming disorder diagnoses, and the apparently likelihood that many scholarly opinions are nuanced, worrying both about the potential addictive qualities of games, but also concerned about moral panic (Ferguson & Colwell, in press).Thus, it appears safe to say there are many divergent opinions on whether pathological gaming should be a standalone disorder as in the ICD with no consensus either for or against the concept. The current study hopes to provide evidence regarding the developmental pathways between pathological gaming and mental health issues in youth.

The inclusion of disorders within diagnostic nosology is seldom based purely in science, but can reflect politics, social narratives and even the incentives within the field of psychiatry itself. We note that recent diagnostic systems such as the American Psychiatric Association's most updated Diagnostic and Statistical Manual (DSM-5) are often the focus of intense debates. Such debates relate to the reliability of the entire system or diagnosis (e.g., Frances, 2011) or whether specific diagnoses are warranted (the prejudicial inclusion of homosexuality in older diagnostic systems being a historical example) to whether specific symptoms result in overdiagnosis (such as whether normal grief is being pathologized as depression in the DSM-5). Decades ago, psychiatrist Thomas Szasz (1960) criticized psychiatric diagnoses as often enforcing cultural mores and restrictions as it did treat real diseases. Although his argument did not win the day, critiques of the validity, reliability and scientific integrity remain to the present day (e.g., Deacon, 2013). Given that moral panics over video games are already well-established to have negatively influenced science in other realms such as video game violence (Bowman, 2016), it is worth giving extra scrutiny to the gaming disorder construct proposed by the WHO.

Prior research regarding pathological gaming and mental health in youth

Various terms have been used to indicate gaming overuse behaviors, ranging from video game addiction to problematic gaming (Kneer & Glock, 2013). For this article we will use the term pathological gaming (PG) which has the advantages of both being widely used (Reyes et al., 2019) and avoids concerns that addiction terminology may result in misleading comparisons to substance abuse.

A considerable amount of research indicates that pathological gaming is associated with a wide range of other mental health concerns, such as anxiety, depression, ADHD and autism spectrum disorders (Mentzoni et al., 2011). Nonetheless, debates remain regarding the conceptual utility of criteria used to measure PG and their ability to indicate clinically relevant syndromes. For instance, several studies have indicated that diagnostic criteria for PG fail to distinguish clinical from non-clinical populations (Colder Carras & Kardefelt-Winther, 2018; Przybylski, Weinstein, & Murayama, 2017; Przybylski & Weinstein, 2019a). Thus, it remains debatable whether PG should be conceptualized as a unique condition, often comorbid with, yet nonetheless distinct from other mental health conditions, or rather as a symptom, risk marker or coping strategy for dealing with mental illness.

Part of the issue involves the developmental pathway between PG and other mental health conditions. In this sense there are three broad possibilities. First, PG may be an originating condition that, once established, leads to further mental health problems. Arguably, this is the position often presented by news media, such as by comparison with heroin or other drugs (e.g., Boudin, 2018). Second, PG and other mental illness are distinct from one another, yet may contribute to each other in a kind of downward spiral. Third, other mental illnesses typically develop first, with PG as a consequent sequelae of mental health issues rather than a unique disorder.

There are two relevant issues to consider. First is the developmental path between PG and other mental health conditions. For example, in the first model, we'd expect longitudinal associations between early PG and later mental illness, but not the inverse. In the second model we'd expect bidirectional paths between PG and mental illness over time. In the third model, we'd expect longitudinal associations between early mental illness and later PG, but not the inverse. The second issue regards whether the conceptualization of pathological gaming presents a stable construct across time. For instance, symptoms related to substance abuse, or food addiction (Cruce & Öjehagen, 2007; Pursey, Collins, Stanwell, & Burrows, 2016) or even "study addiction" (Atroszko, Andreassen, Griffiths, & Pallesen, 2016) tend to show relatively high temporal stability. However, some initial research has indicated comparatively low stability for pathological gaming over time, suggesting such symptoms spontaneously remit, even without treatment (Rothmund, Klimmt, & Gollwitzer, 2018). It is possible that, in some cases, temporary binge use of games may reflect either excitement over new games or a reaction to life stress, with pathological gaming behaviors spontaneously remitting once either the novelty or the stress has worn off. Related to this, some evidence has emerged that pathological gaming develops less due to exposure to games themselves, and more so due to academic and family stress reducing self-control (Jeong, Ferguson, & Lee, 2019). Examining these issues developmentally can help to elucidate the most appropriate diagnostic role for pathological gaming related constructs.

The Singapore database and the current study

One commonly used database examining pathological gaming has been a sample of 3,034 Singaporean youth (e.g., Liau et al., 2015). This database presents a robust examination of multiple issues related to gaming in a large longitudinal sample. However, previous studies using this database, particularly in the realm of violent game research, have also attracted controversy regarding the potential for questionable researcher practices that may have led to spurious false positive results (see Przybylski & Weinstein, 2019b for discussion with specific examples). Some research reexamining the Singapore dataset revealed false positive results related to alleged violent video game effects (Ferguson & Wang, 2019). Given that the same research group was previously involved in both examining pathological gaming as well as the potentially false positive results related to violence in gaming, there is value in taking a closer look at pathological gaming in this sample using preregistered analyses. The preregistration of analyses prior to examining data is one means of reducing false positive results due to questionable researcher practices.

With the current study, we have sought to examine the issue of pathological gaming in a set of preregistered analyses using the Singapore dataset (preregistration available at: https://osf.io/f8zvs). We hereby certify that preregistration occurred before any data analyses were conducted. We also employ the 21-word statement suggested by Simmons, Nelson, and Simonsohn (2012, p. 4): "We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study."

Primary outcomes

Our analyses sought to examine several related issues. First, we sought to examine the temporal stability of pathological gaming over 3 waves of longitudinal data. As such, we test the hypothesis that the construct of pathological gaming will maintain a high degree of stability over the course of 3 longitudinal waves. Though there is less of a clear cutoff for examining stability of a construct as one indication of validity, as there is for reliability ($r = .70$) or statistical significance ($p < .05$), a sophisticated examination of the evidence can help illustrate the overall stability of the pathological gaming construct.

Second, a set of regression analyses will be run predicting wave 3 mental health symptoms from wave 1 pathological gaming symptoms and, inversely, wave 3 pathological gaming symptoms predicted by earlier mental health symptoms (either wave 1 or wave 2 as available in the dataset). Such an analysis can help us in determining the degree to which

Table 1. Main Study Research Questions.

Research Question	Relation To Gaming Disorder Debates
Is Pathological Gaming Stable?	Stability was modest with stability coefficients mainly driven by non-PG youth remaining non-PG, rather than maintenance of PG symptoms over time. Suggests PG is a transitory experience, most often declining naturally over time.
Temporal Order of PG and Mental Health	As a unique disorder requiring its own classification, we expect that early PG symptoms would predict later mental health symptoms. The absence of such longitudinal correlations suggest that PG is merely a symptom of other disorders, not a unique disorder unto itself.
Examining Longitudinal Predictors of PG	By understanding the social predictors of PG symptoms we can better understand the circumstances under which it occurs. Under the gaming disorder model, early time spent on gaming should be a strong predictor of later PG. If other factors are stronger predictors of PG, this once again suggests PG is symptomatic of larger issues, rather than a disorder unto itself.

pathological gaming can predict later mental health symptoms (consistent with the gaming disorder diagnosis) or whether pathological gaming symptoms are themselves largely a sequelae of underlying, preexisting mental health issues (consistent with skepticism over the gaming disorder diagnosis).

Secondary outcome

Lastly, a developmental model will be examined to test the role of social factors (family, stress) and individual factors (self-control, impulse control, anxiety) in the development of pathological gaming. This will help us understand the developmental pathway that can predict pathological gaming over time. To help illustrate out research questions we have provided them in a succinct chart form as Table 1.

Methods

Procedures

A full description of study procedures is available from Ferguson and Wang (2019). For this study, participants included 3,034 students from 6 primary schools and 6 secondary schools in Singapore. The longitudinal aspect of the study involves following this cohort over the three-year period. The second wave of the longitudinal survey study was conducted a year after the first wave and the third wave was conducted a year after the second wave. All students within the general education program at the schools were eligible to participate.

Letters of parental consent were sent to the parents through the schools. A liaison teacher from each school collated the information and excluded students from the study whose parents refused consent. Four sets of counterbalanced (e.g., presented in differing orders to reduce ordering effects) questionnaires were delivered to all the schools for consented students. The questionnaires were administered in the classrooms with the help of schoolteachers at the convenience of the schools. Detailed instructions were given to schoolteachers who helped in the administration of the survey.

Students were told that participation in the survey was voluntary, and they could withdraw at any time. Privacy of the students' responses was assured by requiring the teachers to seal collected questionnaires in the envelopes provided in the presence of the students. It was also highlighted on the questionnaires that the students' responses would be read only by the researchers.

In the second and third years of the project, students who had to be followed-up were no longer in the classes together with their previous cohorts but were in different classes together with other students who did not participate in the project. Surveys were still distributed in class as described above. All schools involved preferred to administer the questionnaires by classes rather than have the selected students taken out of their classes for the study. As a result of this administrative convenience, students not involved in the project were also surveyed but their data was not used for the current study.

Participants

As noted above, for the current study, participants included 3034 Singaporean youth. Regarding gender, 72.8% reported being male. The participants' mean age at time 1 (T1) was 11.21 ($SD = 2.06$). Mean age at time 3 (T3) was 13.12 ($SD = 2.13$). Most participants were ethnic Chinese (72.6%), with smaller numbers of Malay (14.2%), Indian (8.7%) and others. These racial/ethnic proportions are about equal to that for Singapore generally. Participants were surveyed three times at 1-year intervals.

Materials

Likert-scale type items were used for all measures unless indicated otherwise. Individual scale items were averaged to produce full scale scores for each measure unless otherwise indicated below. All control or predictor variables were assessed at wave 1 unless otherwise noted, whereas all outcome variables were assessed at wave 3 unless otherwise noted.

Pathological gaming

The Singapore dataset includes 10 items related to pathological gaming. In examining the items is became apparent that one item related to reducing time spent gaming had been worded in such a way as to be inconsistent with the DSM-5 wording for the similar symptom for internet gaming disorder (specifically that attempts to reduce gaming were unsuccessful). Although a second sub-question (i.e., "If yes are you successful") asked whether such efforts were successful, quantifying two questions into one score appeared fraught and error prone and likely inconsistent in metrics with the remaining 9 items. Thus, this item was not included in the calculation of the pathological gaming scale. This decision was made prior to any data analysis. Coefficient alphas for the remaining items were .73 and Time 1, .67 at Time 2 and .66 at Time 3.

Basic control variables

Several demographic variables are used as standard controls. These include age and sex, maternal education, and time spent gaming at wave 1 in hours/week. Time spent gaming was calculated as the sum spent on weekdays (times 5) and weekends (times 2) for the participants' reported top 3 games. Preexisting variables for hours gaming during the week and on weekends also existed in the dataset. Rerunning the regressions described below using this alternate variable did not change the regression results.

Family environment (control variable)

Given evidence family environment can influence aggression (DeCamp, 2015), a six-item measure of family environment was included (alpha = .77; Glezer, 1984). Sample items include "I feel accepted at home" and "There are too many arguments when living at home."

Impulse control problems (control variable)

Impulse problems were measured using a 14-item scale, which assessed inattentiveness, impulsive behaviors and excitability (Liau, Tan, Chow, Tan, & Konrad, 2011, alpha = .67).

Intelligence (outcome variable)

Intelligence at wave 3 was assessed using the Ravens Progressive Matrices. Previous research indicates the Ravens is a reliable and valid measure of intelligence across cultures (e.g., Shamama-Tus-Sabah, Gilani, & Iftikhar, 2012). Full scale scores were used.

Self-control (outcome variable)

Self-control was measured using a 5-item scale which included items related to handling stress and losing temper (Liau et al., 2011). Coefficient alpha at wave 1 was .62, at wave 2 was .65 and at wave 3 .69. Self-control was measured at all three waves. A sixth item was added at waves 2 and 3, but the self-control score we calculated was based only on the consistent 5 items used at all 3 waves. This decision was made prior to data analysis.

Somatic complaints (outcome variable)

Physical symptoms potentially due to stress were accessed using a 10-item scale related to issues such as back pain, headaches, etc. (Crystal et al., 1994; alpha = .88). Participants were asked how often in the past month they had experienced symptoms such as back pain, trouble sleeping, hand and wrist pain, etc.

Attention deficit/hyperactivity symptoms (ADHD, outcome variable)

ADHD symptoms were measured with an 18-item scale (DuPaul, Power, Anastopoulos, & Reid, 1998; alpha .92 at wave 2 and .93 at wave 3.). Items asked about fidgeting, blurting out answers, and distractibility. This scale was only administered during waves 2 and 3.

Depression (outcome variable)

Depression was assessed using the Asian-American Depression Scale (Woo et al., 2004) to which the original producers of the Singapore database added two additional items ("My sleep was restless" and "My appetite was poor" from Radloff, 1977). Questions asked about hopelessness, thoughts about dying and persistent sadness. Coefficient alpha for this sample was .95 at wave 2 and .96 at wave 3. This scale was only administered during waves 2 and 3.

Anxiety (outcome variable)

Anxiety was assessed using a 20-item scale of child anxiety (Birmaher et al., 1997). Items asked about the degree to which youth experienced nervousness, worrying and fears. Coefficient alpha was .90 at wave 2 and .92 at wave 3. This scale was only administered during waves 2 and 3.

Social Phobia (outcome variable)

Social phobia was assessed using a 17-item scale (Connor et al., 2000). Questions asked about shyness around others, fear of interacting with others, or engaging socially in public. Coefficient alpha was .93 at wave 2 and .92 at wave 3. This scale was only administered during waves 2 and 3.

Preregistration of statistical models

To reduce researcher degrees of freedom all analyses were preregistered (see: https://osf.io/f8zvs). All regressions used OLS with pairwise deletion for missing data. Analyses of VIF revealed lack of collinearity issues for all analyses, with no VIF outcomes reaching 2.0.

Results

Stability of pathological gaming over time

At present, no clear clinical guidelines exist regarding the diagnosis of pathological gaming related constructs. Although the DSM-5 in their internet gaming disorder category for future study suggest five of nine criteria are necessary for diagnosis, research suggests this threshold results in a high degree of false positives (Przybylski et al., 2017; Przybylski & Weinstein, 2019). Thus, for the present study, those higher than 2 standard deviations above the mean on the pathological gaming variable were identified for each wave. As such, participants were given a binary code of whether they met the 2 SD standard or not.

In terms of raw correlations between the continuous pathological gaming variables, correlations were small to moderate and statistically significant. The correlation between pathological gaming at wave 1 and wave 2 (1 year apart) was $r = .467$ ($p < .001$). The correlation between pathological gaming at wave 1 and wave 3 (2 years apart) was $r = .401$ ($p < .001$). However, when considering the dichotomous classification at 2 SDs, evidence for stability was weaker. The binomial correlation between pathological gaming at wave 1 and wave 2 (1 year apart) was $r = .243$ ($p < .001$). The correlation between pathological gaming at wave 1 and wave 3 (2 years apart) was $r = .110$ ($p < .001$). The latter score is approaching that which is sometimes considered to have a high degree of false positive results due to methodological noise (Orben & Przybylski, 2019, who recommend $r = .10$ as a cutoff for interpretation as hypothesis supportive results). As such, extreme scores are only weakly correlated over time.

This issue can be examined in another way. At wave 1, 117 youth scored at 2 SDs above the mean. At wave 2, only 26 of those youth (22.2%) of those youth continued to endorse extreme scores. By wave 3 only 14 (12.0%) continued to endorse extreme scores. As such, it appears that, in most cases, endorsement of high pathological gaming symptoms doesn't remain stable over time.

Regressions predicting wave 3 outcomes

To examine the degree to which pathological gaming predicted cognitive, behavioral or mental health outcomes among Singaporean youth, several

Table 2. Standardized Regression Weights for All Regressions with Behavioral Outcomes.

Predictor	Intelligence	Somatic	SC	ADHD	Dep	Anx	Social
Age	.374*	.078	.048	.130*	.050	.055	.023
Gender	.033	.073	−.061	−.017	.057	.047	.040
PG Wave 1	−.183*	.057	−.045	.096	.045	.052	.078
Gaming time	−.018	.041	.024	.009	.013	−.030	−.024
Mother ed.	.004	−.034	.008	.025	−.017	.004	−.029
Family env.	.157*	−.058	.085	−.071	−.098	−.037	−.023
Impulse Control	.019	.041	−.115*	.143*	.051	.049	.038
W1 or W2 Outcome	.300*	.270*	.269*	.363*	.435*	.436*	.403*

Note. *Denotes variables that are both "statistically significant" and also reached the $r = .10$ threshold for interpretation so as to avoid false positive interpretations.

ordinary least squares (OLS) regressions were run. In addition to pathological gaming at wave 1, several other control variables were included. These included age, sex, time spent gaming, mother's education level, family environment, and impulse control. Further, for each outcome the wave 1 score (if available) or wave 2 score (if wave 1 was not available, as for ADHD, depression, anxiety and social anxiety) was used as a control variable. Pairwise deletion was used for all regressions.

With large samples a particular issue arises in that very tiny effects can sometimes become "statistically significant" due to the high power inherent in large samples. However, there is concern that tiny but "statistically significant" effects may often represent noise due to methodological issues such as common methods variance in survey design, demand characteristics, single responder bias, etc., and, as such, may represent false positive results (Ferguson, 2009; Ferguson & Wang, 2019; Orben & Przybylski, 2019). Thus, we are following these concerns by establishing a cutoff of $r = .10$ in addition to statistical significance as a threshold for interpretation. This decision was made prior to any data analysis.

First, regarding bivariate correlations, pathological gaming had small, but statistically significant (all $p < .01$) relationships with all outcome variables. These included intelligence ($r = -.203$), somatic complaints ($r = .157$), self-control ($r = -.127$), ADHD ($r = .291$), depression ($r = .208$), anxiety ($r = .150$) and social anxiety ($r = .152$). Though statistically significant, many of these relationships are quite small and the question remains whether these might be explained by third variables.

All OLS regression results for pathological gaming predicting outcomes are summarized in Table 1. Standardized regression scores are used (Table 2).

For intelligence as measured by the Ravens the full model was statistically significant [$R = .570$, $_{adj}R^2 = .311$, $F\ (8, 371) = 22.37$, $p < .001$). As is evidence from the degrees of freedom, the Ravens score was only available for a smaller subset of individuals at wave 3. Among this sample, age ($\beta = .374$), pathological gaming ($\beta = -.183$) positive family environment ($\beta = .157$) and the wave 1 Ravens score ($\beta = .300$) were predictive of wave 3 intelligence (all *p*s < .001). Time spent gaming itself was not a predictor ($\beta = -.018$). All VIFs were below 2.0 indicating lack of collinearity issues.

For somatic complaints the full model was statistically significant [$R = .365$, $_{adj}R^2 = .129$, F (8, 1,846) = 35.46, $p < .001$). For this outcome only the wave 1 somatization score ($\beta = .270$, $p < .001$) was predictive of wave 3 somatization. Neither pathological gaming ($\beta = .057$) nor time spent gaming itself ($\beta = .041$) reached the criteria for significance. All VIFs were below 2.0 indicating lack of collinearity issues.

For self-control the full model was statistically significant [$R = .381$, $_{adj}R^2 = .142$, F (8, 1,801) = 38.28, $p < .001$). For this outcome only impulse control problems ($\beta = -.115$, $p < .001$) the wave 1 self-control score ($\beta = .269$, $p < .001$) were predictive of wave 3 self-control. Neither pathological gaming ($\beta = -.045$) nor time spent gaming itself ($\beta = .024$) reached the criteria for significance. All VIFs were below 2.0 indicating lack of collinearity issues.

For ADHD symptoms the full model was statistically significant [$R = .541$, $_{adj}R^2 = .290$, F (8, 1,833) = 94.79, $p < .001$). Significant predictors of wave 3 ADHD symptoms included age ($\beta = .130$), impulse control problems ($\beta = .143$) and the wave 1 ADHD symptoms ($\beta = .363$) (all *p*s < .001). Time spent gaming itself was not a predictor ($\beta = .009$), nor were pathological gaming symptoms at wave 1 ($\beta = .096$). All VIFs were below 2.0 indicating lack of collinearity issues.

For depressive symptoms the full model was statistically significant [$R = .561$, $_{adj}R^2 = .312$, F (8, 1821) = 104.74, $p < .001$). For this outcome only the wave 1 depressive symptoms ($\beta = .470$, $p < .001$) was predictive of wave 3 depressive symptoms. Neither pathological gaming ($\beta = .045$) nor time spent gaming itself ($\beta = .013$) reached the criteria for significance. All VIFs were below 2.0 indicating lack of collinearity issues.

For anxiety symptoms the full model was statistically significant [$R = .478$, $_{adj}R^2 = .225$, F (8, 1826) = 67.47, $p < .001$). For this outcome only the wave 1 anxiety symptoms ($\beta = .435$, $p < .001$) was predictive of wave 3 depressive symptoms. Neither pathological gaming ($\beta = .052$) nor time spent gaming itself ($\beta = -.030$) reached the criteria for significance. All VIFs were below 2.0 indicating lack of collinearity issues.

For social phobia symptoms the full model was statistically significant [$R = .441$, $_{adj}R^2 = .191$, F (8, 1,797) = 54.37, $p < .001$). For this outcome only the wave 1 social phobia symptoms ($\beta = .403$, $p < .001$) was predictive of wave 3 depressive symptoms. Neither pathological gaming ($\beta = .078$) nor time spent gaming itself ($\beta = -.024$) reached the criteria for significance. All VIFs were below 2.0 indicating lack of collinearity issues.

Regression predicting wave 3 pathological gaming

To examine the degree to which wave 3 pathological gaming was predicted by mental health conditions an ordinary least squares (OLS) regression was run. In addition to pathological gaming at wave 1, several other control variables were included. These included age, sex, time spent gaming, mother's education level, family environment, and impulse control. Main predictor variables included the wave 2 scores for mental health symptoms related to ADHD, depression, anxiety and social anxiety. Pairwise deletion was used for the regression.

The full model was statistically significant [R = .505, ${}_{adj}R^2$ = .251, F (11, 1806) = 56.32, p <.001). Pathological gaming at wave 3 was predicted by male gender, (β = .120), wave 1 pathological gaming (β = .268) but not time spent gaming at wave 1 (β = .015). Regarding mental health symptoms, pathological gaming was predicted by ADHD (β = .160) and depressive symptoms (β = .128) at wave 2, but not anxiety (β = .054) or social phobia symptoms (β = .014). All VIFs were below 2.0 indicating lack of collinearity issues.

Structural equation model

A structural equation model which was preregistered was run as part of our analysis. For the validity of the latent factors several individual items were deleted from several variables. The pathological gaming measure for the SEM used six items (items related to borrowing money to play games, thinking about games and using games to escape from problems were removed). Two items related to losing temper and getting upset easily were removed from the self-control variable resulting in a three-item scale. Sixteen items were adopted for the anxiety scale by dropping out four items (related to headaches, not enjoying being around strangers, worrying about other people liking them and stomachaches). For measuring family environment, two items about feeling uncomfortable and many arguments when living at home were removed. Finally, for the impulse control measure, three items were used (I let others finish what they are saying; I concentrate easily; I finish what I start). Note that these decisions to trim the scales for use in the SEM were made only to ensure the validity of the latent variables and were not made to influence the theoretical models (see Table 3).

In the model, we tested whether wave 1 family environment, gaming time and impulse control were related to the mediating wave 2 variables of anxiety and self-control with these, in turn predicting wave3 pathological gaming. This model has similarities to the social stress model of pathological gaming proposed by Jeong et al. (2019). Wave 1 pathological

Table 3. Reliability and Discriminant Validity of SEM Constructs.

Constructs	# of measures	Mean (S.D.)	Cronbach Alpha	CR AVE
Pathological gaming (w1)	6	.246 (.226)	.711	.953 .773
Anxiety	16	.663 (.425)	.891	.721 .515
Self-control	3	2.923 (.627)	.735	.824 .610
Family environment	4	3.313 (.602)	.733	.820 .540
Impulse control	3	2.956 (.586)	.709	.771 .530
Pathological Gaming (w3)	6	.184 (.218)	.785	.974 .862

Note. SD: Standard Deviation; CR: Composite Reliability; AVE: Average Variance Extracted. Scale scope: pathological gaming (0–1), anxiety (0–2), others (1–4).

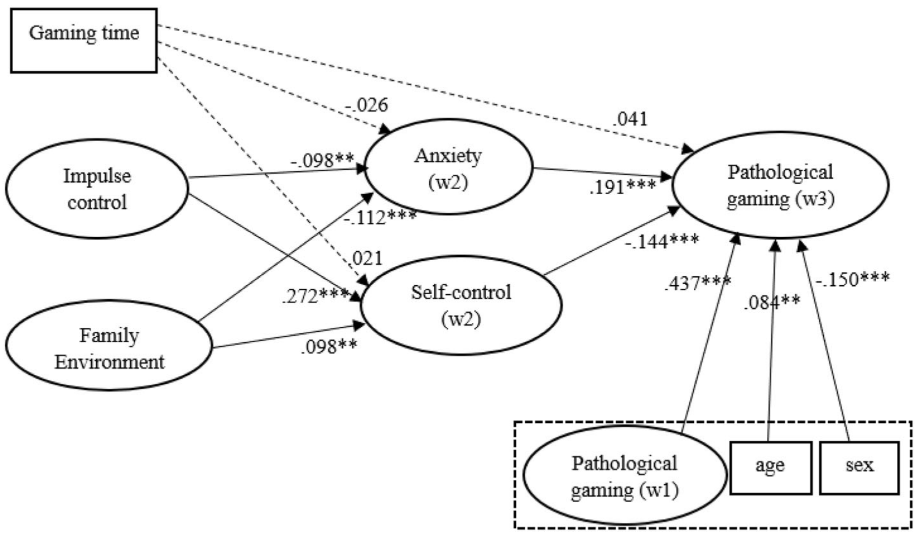

Figure 1. Social stress model of pathological gaming.

gaming, as well as age and sex were used as control variables. This model was a good fit to the data (IFI = .928, TLI = .906, CFI = .928, RMSEA = .031). The model is presented as Figure 1. Time spent gaming did not predict any outcomes, however impulse control and family environment predicted the wave 2 outcomes which, in turn, predicted wave 3 pathological gaming. This supports a social stress model, in this case through family environment issues.

Exploratory analyses

We tested several issues to examine with methods variances issues may have influenced our results. As noted in the methods section, we eliminated one item due to concerns about its wording and difficulty construing a response from a two-part question. However, some might object that eliminating this item might not fully capture the concept of pathological gaming. In the original dataset, the pathological gaming variable had been calculated three ways, weighted by the response on the second part of the question (whether they could, couldn't or sometimes controlled their game time. As such, we used these preexisting variables in our regression equations, replacing the pathological gaming variable we preregistered. In no case did the results substantially change (in fact in some cases, as with ADHD, effect sizes became smaller, $\beta = .054$). As such we can be sure that the elimination of this one item did not artificially deflate effect sizes.

Another possible critique is that by controlling for early impulse control problems, we removed a core conceptual component of pathological gaming. Arguably, this goes to the argument of whether pathological gaming is a stand-alone disorder, or symptomatic of larger, underlying issues (such as a more general impulse control problem.) Rerunning our regressions with the impulse control variable removed as a control variable once again did not result in substantive changes in most outcomes. The only exception was ADHD which moved just above our threshold for interpretation ($\beta = .121$). Thus the control of T1 impulse control problems does not appear to be a key factor to the majority of our results with the exception of ADHD.

Discussion

Issues related to pathological gaming remain contentious both in the public debate, among professional advocacy and health organizations and among scholars. At present, much contention remains whether pathological gaming is best considered as a unique mental health condition consistent with the approach taken by the World Health Organization, or better considered a symptom or red flag of other, well-established, mental health conditions such as depression or ADHD. From our study we find several things. First, the construct of pathological gaming is not highly stable over time. To the extent that it is stable, this stability appears to come from youth ranking low in symptoms, rather than maintenance of high symptoms over time. Second, preexisting mental health outcomes such as depression or ADHD appear to predict later pathological gaming. However, early pathological gaming does not predict later mental health symptoms. Third, time spent gaming does not appear to be a significant predictor of either pathological gaming, nor mental health outcomes. Negative family environment and poor impulse control tended to lead to mental health symptoms which, in turn, led to pathological gaming symptoms. This suggests a developmental course from families through mental health, then finally to excess play, likely used to reduce those mental health symptoms. Taken together, these pieces of evidence suggest that the diagnostic approach to pathological gaming taken by the WHO is not consistent with this data, and pathological gaming symptoms are better considered as sequelae of other mental

Table 4. Summary of Main Findings Related to Research Questions.

Research Question	Relation To Gaming Disorder Debates
Is Pathological Gaming Stable?	Pathological gaming symptoms have proven transitory in some prior research. This suggests symptoms may be context or situation specific rather than a disorder which requires treatment to dissipate.
Temporal Order of PG and Mental Health	Evidence suggested that PG symptoms did not predict later mental health symptoms. However, mental health symptoms did predict later PG. This suggests that PG symptoms are the consequence of preexisting mental health issues, not a unique disorder.
Examining Longitudinal Predictors of PG	SEM analyses in particular suggest a developmental course from negative family environments and poor impulse control to symptoms of anxiety and reduced self-control and, from these, to PG. This suggests that PG is a mechanism used to elevate mood and is a symptom, not a cause of mental health difficulties.

health or social circumstances. We provide a summary of our main findings and how these relate to our original research questions as Table 4.

Only one outcome was related in wave 3 to early pathological gaming symptoms, namely intelligence as measured by the Ravens. This longitudinal effect was quite small, but larger than our threshold for interpretation so it is not without some importance. We note that, even in longitudinal designs, a third maturational variable could explain temporal links between two variables. As such, we must be cautious in making causal attributions. One speculation is that pathological gaming may pull youth away from academics, resulting in those youth falling behind in terms of their intellectual development. It is also possible that individuals who are in the early stages of struggling academically, may turn to games as a coping mechanism, even as intellectual disadvantages increase over time.

The lack of relationship between gaming time and any outcome including pathological gaming is quite interesting. Much of the dialogue on pathological gaming has focused on what aspects of games themselves may encourage pathological use. Although we certainly still encourage these lines of research, the current data suggests that gaming exposure itself is not a particularly salient aspect in the development of pathological gaming. In this sense, focusing overmuch on gaming mechanisms may distract parents, society and policy makers from other, more important factors involved in the development of pathological gaming and other mental health outcomes.

The SEM model supported a social stress understanding of pathological gaming. Specifically, although internal issues such as impulse control influence the course of pathological gaming, so too does family environment in this model. These results were a bit more nuanced than the regression model which found no direct relationship between family environment and later pathological gaming. Similar to the results of Jeong et al. (2019), it may be that family environment indirectly relates to pathological gaming by increasing stress and anxiety.

The exploratory results suggest our outcomes are largely stable across various methodological choices. The exception was that removing the impulse control variable moved the relationship between pathological gaming and later ADHD into our threshold for interpretation, although the effect size remained very small ($\beta = .121$). Such a small effect sizes is likely not sufficient to indicate the validity of the pathological gaming construct, though it suggests there is some small relationship between the two concepts. However, this issue also cuts to the crux of the argument about pathological gaming … should it be considered a stand-alone diagnosis, or part of a larger constellation of issues. We argue that this relationship between impulse control problems and pathological gaming, even if considered of clinical significance, might suggest pathological gaming symptoms are indicative of broader impulse control issues, not a stand alone disorder.

Clinical and developmental implications

The lack of relationship between pathological gaming and mental health outcomes fits other recent scholarship (e.g., Przybylski et al., 2017; Przybylski & Weinstein, 2019) which raises concerns about the conceptualization and diagnosis of pathological gaming. Given that the DSM-5 symptoms for the proposed category of "internet gaming disorder" were largely borrowed, with little change, from substance abuse symptoms, it is possible these symptoms simply don't work well for the diagnosis of pathological gaming. This is not to say that pathological gaming does not exist, rather than it is necessary for a new, fundamental research stream to examine which criteria do and do not work in distinguishing pathological gamers from those who are merely highly engaged (Colder Carras & Kardefelt-Winther, 2018; Kaye, Kowert, & Quinn, 2017). At present, current diagnostic criteria have no clarity regarding the sensitivity and specificity of these criteria in making pathological gaming diagnoses and there is evident reason to expect that false positive rates are likely unacceptably high.

The developmental pathway toward pathological gaming, or between pathological gaming and mental health symptoms appears to differ from what may be assumed by many policy makers or potentially even the WHO. Pathological gaming does not seem to progress primarily from exposure to video games, but rather progresses as a consequence of preexisting mental health issues, potentially in combination with stress from social elements such as schools and family (Jeong et al., 2019). This means that, rather than focusing on pathological gaming as a noxious element of the gaming hobby, or one which can be addressed primarily via changes to the games industry, a more nuanced approach that focuses on broader mental health issues and social stress may be more productive. This doesn't mean that the games industry is unable to provide any support to players who may be struggling to moderate their gaming. There may be reasonable steps that the games industry might employ, such as spending limits for microtransactions, reminding players how long they've been playing, etc., that are relatively non-intrusive. However, a public policy approach which prioritized the regulation of games themselves appears unlikely to have much impact on the phenomenon of pathological gaming.

A related concern is that focusing on games as the problem, via "gaming disorder" or "internet gaming disorder" may come with real clinical risks. First, unsuspecting families may seek treatment via centers that are unreasonably expensive, or which offer untested or even harmful therapies to youth. Second, a focus on treating gaming behaviors could distract clinicians from the more critical underlying mental health disorders that led to pathological gaming in the first place. In some cases, clinicians might inadvertently remove a coping mechanism, albeit one that is overused, leaving youth with even fewer resources to manage their stress.

Limitations

As with any study, this one has limitations. First, the data in this study are correlational, and thus no causal attributions can be made. Second, although the pathological gaming survey had 10-questions, the multiple-part structure of one question related to reducing gaming made it difficult to quantify on a scale similar to the other nine items and so it was discarded. Although we have little reason to believe this decision had substantial impact on the results, it is obviously best to maintain all items in the same metric. Third, the current database didn't allow for a thorough exploration of multiple family, peer and academic social stresses that might lead to pathological gaming symptoms. Fourth, our sample is conducted with a specific sample of Singaporean youth and so generalization to other populations is not possible. Related to the limits of generalizing the current findings beyond Singapore, disorders can sometimes cluster in particular areas due to the social circumstances and stresses of those areas (Carrà, Crocamo, & Bebbington, 2017). This may also be true for pathological gaming issues in Singapore and, as such, current results must be understood within a Singapore context. Fifth, not all potential control variables were available for this dataset. For example, it would be worth considering the impact of other potential confounders such as child literacy, paternal education, the use of psychiatric medications or socioeconomic status in future studies. Finally, this study examined a pathological gaming disorder through the lens of ADHD and depression. It did not bring into the equation other well-established disorders (e.g., anxiety) or other addictive/ impulse control disorders (such as pathological gambling or other addictive behaviors).

Conclusions

It is clear to us that the field of pathological gaming is significantly limited due to considerable reliance on non-preregistered studies without standardized measurements for the pathological gaming construct. Further, the decision to base pathological gaming symptoms on substance abuse symptoms may have been a critical mistake. We feel it is necessary, in many respects, for the pathological gaming research field to have a "do over" with more rigorous studies examining the conceptual utility of pathological gaming as a construct and the criteria by which it might be understood. Our current data suggest that conceptualizing pathological gaming as a stand-alone disorder such as emphasized by the WHO is not well-supported by data and has the potential to do more harm than good. However, more rigorous data using standardized assessments and preregistered analyses can help us to elucidate this issue further.

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