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Time Spent Gaming, Depressive Symptoms, and Behavioral Activation: A Longitudinal Mediation Study on Predictors of Gaming Disorder (47 PP.)

Thesis Advisor: William V. Lechner

Time spent gaming and depressive symptoms are both variables that the extant literature has identified to have associations with gaming disorder. However, most research that examined time spent gaming as a variable of interest have relied on participant self-report. This study incorporates objective measures of time spent gaming via logged behavioral data, specifically examining longitudinal relationships between time spent gaming, depressive symptoms, and gaming disorder. Additionally, behavioral activation level was examined as a potential mediator of these variables. 98 North American League of Legends and Teamfight Tactics players (82.7% male), with an average age of 22.34 years (SD = 3.67), were recruited to complete three waves of measures assessing negative emotion and game play characteristics over the course of two weeks. The participants also provided consent to link their accounts' behavioral data to their responses. Meaningful differences between objective logged data and subjective self-report estimates of time spent gaming (absolute difference = 5.20 h per week, SD = 7.66) were observed. Self-reported time spent gaming was associated with decreased levels of behavioral activation which in turn were associated with elevated gaming disorder symptoms. Similarly, depressive symptoms were associated with increased gaming disorder symptoms via lower behavioral activation levels. These effects were no longer significant when baseline values of subsequent variables in the mediation

path were controlled for. Logged data on time spent gaming did not demonstrate the same pattern of results as self-report. Substantial differences between objective logged data and subjective self-report estimates of time spent gaming align with previously reported discrepancies observed in other studies examining technology use. Significant longitudinal relationships were observed for subjective self-report estimates of time spent gaming and depressive symptoms on gaming disorder through behavioral activation levels. Observational studies involving different time windows and assessment frequencies, along with experimental studies involving manipulation of time spent gaming and interventions addressing depressive symptoms and or behavioral activation over time, are needed to further inform research and treatment efforts for gaming disorder.

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Jackson Jin

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Thesis written by

Jackson Tianran Jin

B.A., University of Southern California, 2019

M.A., Kent State University, 2023

Approved by

_____, Advisor

William Lechner, Ph.D.

_____, Chair, Department of Psychological Sciences

Maria Zaragoza, Ph.D.

_____, Dean, College of Arts and Sciences

Mandy Munro-Stasiuk, Ph.D.

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Introduction

Video gaming has become an increasingly popular recreational activity. A national study in the United States on video game use reported that 88% of American youth between ages of 8 to 18 played video games at least occasionally (Gentile, 2009). This was especially apparent during lockdown periods of the COVID-19 pandemic, when many people turned to online activities like video gaming as offline options were limited (Barr & Copeland-Stewart, 2022). As the general population's interest in video gaming has grown, so has academic interest on the topic (Barlett et al., 2009; Weinstein et al., 2017). These studies include examining positive effects of video gaming such as improved cognitive effects (Anguera et al., 2013; Blumberg et al., 2013; Green & Bavelier, 2015; Choi et al., 2020) and emotional benefits (Yeh, 2015; Pallavicini et al., 2018; Halbrook et al., 2019; Hazel et al., 2022). For youth populations, video gaming has been found to be beneficial across a variety of domains such as problem-solving skills and intergroup relationships (Adachi & Willoughby, 2017). For aging populations, video gaming may help enhance several aspects of cognitive functioning such as reaction time, attention, and memory (Toril et al., 2014). However, several problematic relationships have also been studied, including associations with aggression (Willoughby et al., 2012; Prescott et al., 2018; Przybylski & Weinstein, 2019; Chen et al., 2023) and patterns of behavior that appear to share similar aspects to addictions (Chiu et al., 2004; Griffiths et al., 2012; Stockdale & Coyne, 2018; Plante et al., 2019). Concerns about the negative impact of video gaming specifically pertain to excessive and harmful engagement with video gaming at the expense of personal wellbeing, relationships with others, and impairments to

functioning (Teng et al., 2020). These problematic gaming behaviors have also been found to be associated with existing psychopathologies (González-Bueso et al., 2018) and cognitive deficits (Billieux et al., 2020). From individual case studies (Torres-Rodríguez et al., 2019) to systematic reports (Wang & Cheng, 2022), problematic gaming has garnered increased attention from researchers, clinicians, and policymakers. This has led to proposals for a clinical diagnosis to capture the phenomenon (King & Delfabbro, 2013).

Specifically, to address growing concerns regarding problematic gaming behavior, the World Health Organization has added gaming disorder (GD) as a new clinical condition in the 11th edition of the International Classification of Diseases (ICD-11) under "Disorders due to Addictive Behaviors." The condition is defined as a persistent pattern of problematic gaming behaviors that consists of impaired control over and increased priority given to gaming, and continuation of gaming behavior despite negative life consequences (World Health Organization, 2019). The American Psychiatric Association has also proposed a similar diagnosis, internet gaming disorder, as "condition requiring further study" in their 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), which remains the case in the recently published DSM5-TR (American Psychiatric Association, 2022). While it is to be determined whether the APA will update its next edition of the DSM to incorporate IGD as a formal clinical diagnosis, it is apparent that problematic gaming behavior has become increasingly researched and contended topic among researchers and clinicians alike (Wang et al., 2019; Mestre-Bach et al., 2022). Those against the inclusion of the diagnosis cited low research quality, stigmatization of healthy gaming behavior, and lack of consensus on assessment methodology (Aarseth et al., 2017; Van Rooij et al., 2018). On the other hand, those in support of the diagnosis argued that the classification is necessary for directing research and clinical efforts, and that its sole focus on functional

impairment of individuals with problematic gaming behaviors would not come at the cost of stigmatizing gaming for individuals who engage in gaming without impairment to functioning (Király & Demetrovics, 2017; Griffiths et al., 2017). It is also argued that the necessity of a GD diagnosis stems from growing public health needs, as existing health services for individuals engaging in problematic gaming remain scarce (Rumpf et al., 2018). Nonetheless, researchers on both sides have conceded that more quality research on GD is required before robust conclusions can be drawn (Billieux et al., 2017; Carras et al., 2020).

Prevalence Rate of GD

Past research on prevalence rate of GD have yielded mixed results, with rates ranging from as low as 0.21% to as high as 57.50% in general populations (Darvesh et al., 2020). This is due to variations in sampling methods and screening tools (Stevens et al., 2021). After the decision from the World Health Organization to include GD as an official diagnosis, a large-scale cross-sectional study using specifically both ICD-11 and DSM-5 criteria on an international sample yielded a prevalence rate of 1.96% using the ICD-11 criteria for GD, which is lower than a rate of 4.97% when using the proposed criteria for IGD in the DSM-5 (Pontes et al., 2022). The significant difference in prevalence rate between the two criteria used can be attributed to the inclusion of items in the DSM-5 criteria for IGD pertaining to: (1) Tolerance, the need for increased amount of time spent engaged in video gaming, (2) deception, having deceived others regarding the amount of engagement in video gaming, and (3) alleviation of negative moods, specifically using video gaming to escape from or relieve negative emotions (Castro-Calvo et al., 2021). In contrast to the DSM-5 criteria for IGD, the more narrowly defined ICD-11 criteria for GD does not include these criteria (Wang & Cheng, 2020). However, regardless of the criteria in question, both rates are comparable to global prevalence rates of depressive and anxiety disorders, as well as substance

use disorders (Castaldelli-Maia et al., 2022). Considering that a significant percentage of the global population engages in video gaming, these prevalence rates indeed highlight a growing public health need for further research efforts to understand GD, regardless of whether it remains a diagnosable clinical condition or not.

Time Spent Gaming and GD

Examining the relationship between time spent gaming and GD is one of particular importance given existing and proposed governmental policies emerging in recent years that primarily focus on reducing time spent gaming via limiting access to gaming services (Király et al., 2018). The rationale of these approaches relates to the time displacement hypothesis (Robert, 1995). This hypothesis proposes that individuals with elevated levels of online communication are at risk for decreased wellbeing or negative emotion due to less time spent in face-to-face interactions with real life friends and family (Valkenburg & Peter, 2007). This is not completely unfounded in the context of video gaming, as time spent gaming has been found to be associated with GD in previous studies (Gentile et al., 2011**;** Pontes et al., 2022).

While face validity may suggest that focusing on reducing time spent gaming to address GD is appropriate, the extant literature often includes a critical limitation – the reliance on participant self-report estimates to measure time spent gaming. While utilizing self-report is understandable due to its convenience and the lack of access to objective measurements via in-game data, self-report estimates have been found to have significant discrepancies with more objective methodologies of accessing technology use (Kahn et al., 2014; Jones-Jang et al., 2020; Sewall et al., 2020). These consistent discrepancies point to potential risks of systematic bias when relying on subjective self-report estimates on technology use from participants alone (Parry et al., 2021). To address this limitation, researchers called for more research on GD that incorporates behavioral

measures of player behavior (Griffiths & Pontes, 2020; Shi et al., 2021). Recent studies on video gaming have begun to incorporate objective measures of time spent gaming in their design. For example, one study examined the relationship between time spent gaming and wellbeing using participant behavioral data obtained through collaborations with the industry (Electronic Arts and Nintendo America), which discovered a small positive association between time spent gaming and increased wellbeing (Johannes et al., 2021). This subsequently led to a longitudinal study with similar design, which yielded non-significant results (Vuorre et al., 2021). Another cross-sectional study conducted by authors of the current manuscript specifically examined associations between objective measures of time spent gaming and GD in a sample of North American League of Legends players, revealing a small positive association between objective logged data on time spent gaming and GD (Jin et al., 2022). Specifically, the authors concluded that it would require a 21 hour increase in time spent gaming per week in order to observe a 1 SD increase in gaming disorder symptoms (Jin 2022). However, no longitudinal studies have directly examined the relationship between objective measures of time spent gaming and GD. Furthermore, no longitudinal studies have examined potential mediators between these variables.

Depressive Symptoms and GD

Identified risk factors for GD in the extant literature include mental health symptoms (González-Bueso et al., 2018), personality traits (Şalvarlı & Griffiths, 2021), and demographics (Mihara & Higuchi, 2017). Among these risk factors, depressive symptoms demonstrated one of the most consistent relationships with problematic gaming patterns (Burleigh et al., 2018; Liu et al., 2018; Bonnaire & Baptista, 2019). For example, a 12-month follow-up study involving elementary school children discovered evidence suggesting a reciprocal relationship between depressive symptoms and GD over time (Jeong et al., 2019). Recent studies conducted during the

COVID-19 pandemic have also found significant relationships between depressive symptoms and GD over time (Teng et al., 2021). One prevalent theory that explains the relationship between depression and GD is the compensatory theory (Kardefelt-Winther, 2014a). This theory proposes that GD stems from underlying negative emotions such as depressive symptoms that predate the onset of GD and calls for examination of potential mediators to help better understand the relationship. One potential mediator of this relationship that has yet to be examined is behavioral activation. Individuals with depressive symptoms often lack motivation to engage in relationships, goal directed activities, and responsibilities (Hopko et al., 2011). It is possible that diminished engagement in valued activities results in an increased reliance on gaming to derive reward, which may have a lower threshold for engagement, and in turn, increase problematic gaming behaviors.

Behavioral Activation and GD

Behavioral activation is an intervention focus for an empirically supported modality of psychotherapy treatment of the same name commonly utilized for treating depression. It specifically refers to the ability of individuals to engage in enjoyable and fulfilling activities in their daily lives (Kanter et al., 2010). In the context of treatment, this is accomplished through a variety of interventions such as activity monitoring, activity scheduling, and can include contingency management (Lejuez et al., 2001). Behavioral activation has been shown to serve as an effective treatment for depression, both as a standalone intervention or when integrated into other treatment modalities (Cuijpers et al., 2007; Stein et al., 2021). Measurement of behavioral activation levels is also relevant to GD as a variable of interest, considering that a hallmark symptom of GD is the increased prioritization of video gaming over other activities (World Health Organization, 2019). For instance, low behavioral activation levels may contribute to the inability to pursue other meaningful and naturally rewarding activities as seen in individuals with depressive

symptoms due to a lack of motivation to do so (Miller & Markman, 2007). Indeed, behavioral activation has been proposed as an important treatment element for GD (Sakuma et al., 2017; Pornnoppadol et al., 2020; Zajac et al., 2020). While the extant literature on links between depressive symptoms and GD suggest that behavioral activation levels may be a key variable to target, no studies have examined the relationship between these variables within a longitudinal design.

Present Study

The current study utilizes a longitudinal design to examine the effect of time spent gaming and depressive symptoms on GD in a sample of North American League of Legends and Teamfight Tactics players. All participants consented to linking their accounts' gameplay activity to their symptoms of negative emotions. League of Legends and Teamfight Tactics are different genres of video games, the former a Multiplayer Online Battle Arena game and the latter an Auto Chess game. Auto Chess games like Teamfight Tactics do not involve direct control of in-game characters in real time. They can therefore be regarded as more oriented towards casual players when compared to Multiplayer Online Battle Arena games such as League of Legends. Distinct video game genres were included in order to increase generalizability of results.

The study's primary aims are to: (1) Evaluate whether time spent gaming (assessed via self-report as well as objective logged data) predicts GD symptoms across 3 timepoints over a span of two weeks. (2) Evaluate whether depressive symptoms predict GD symptoms across the same time frame. (3) Examine the potential mediating role of behavioral activation levels in both relationships. Based on extant literature, our hypotheses are as follows: (1) Both objective logged data and subjective self-report estimates of time spent gaming would be significant predictors of GD over time, (2) depressive symptoms would predict GD over time, (3) behavioral activation

levels would serve as a significant mediator of time spent gaming on GD over time. That is, increased game time will be associated with decreased behavioral activation levels, and subsequently increased GD symptoms. (4) Behavioral activation levels would also mediate the relationships between depressive symptoms and GD over time. That is, increased depressive symptoms will be associated with decreased behavioral activation levels, and subsequently increased GD symptoms.

Methods

Participants and Procedure

The recommended sample size for longitudinal mediation analysis was derived from estimates provided by Pan et al (2018). It is estimated that a sample size of N=54 would be required to achieve adequate power for the planned mediation analysis (.80) to detect the effect via bootstrap method. All referenced Pearson's correlations from cited studies were converted to Cohen's d for interpretation (Rosenthal, 1994). The effect size of depressive symptoms on behavioral activation levels is expected to be large (r=.72 -> d = 2.07; Kanter et al., 2008) and the effect of behavioral activation levels on GD is expected to be halfway between small to medium (r=.12-.23 -> d = 0.24-0.47; González-Roz et al., 2018). The maximum within-subject correlation of 0.9 is assumed due to the short time lapse (1 week apart) between each individual measure point. Thus, to achieve adequate power (.80) with an expected combination of large to small /medium effect sizes for 3 observations, the recommended sample size is estimated to be N=54. However, to account for as the potential for diminished power due to limitations inherent in internet research such as non-attentive responding (Przybylski, 2016), additional participants were recruited above the recommended sample size.

North American League of Legends and Teamfight Tactics players were recruited from online gaming communities and incentivized to participate through gift cards. Participants were instructed to fill out 3 waves of psychological and behavioral measures over a period of 2 weeks, with 1 week gap between each assessment. All measurements were hosted on Qualtrics, with links

directly sent to individual participants through Discord, an instant messaging social platform. All procedures were approved by the Kent State University Institutional Board prior to data collection. 101 participants completed the questionnaire at first wave with no attrition. 3 participants were excluded due to failing attention checks. This leaves a final total number of N=98 participants that were included in the study sample.

Measures

Time Spent Gaming

Time spent gaming was assessed through four measurements (1) objective logged data, (2) subjective self-report and (3-4) adjusted assessment incorporating objective logged data and subjective self-report. These four measurements are defined as follows (1) Objective logged data: Individual time spent per match in game (hours and minutes per week) during the 3-week period were collected from each participant's game account. This approach has the added benefit of excluding time not spent actively engaged in video gaming behavior (e.g., idling on title screen, using other features of the video games unrelated to video gaming behavior). It addresses a concern highlighted in previous studies, which have highlighted the inclusion of time not spent actively engaged in gaming behavior as a methodological limitation (Johannes et al., 2021). (2) Subjective self-report: participants were asked to retrospectively report the total time (hours and minutes) they spent actively playing League of Legends or Teamfight Tactics each week during study participation. (3-4) Adjusted assessment: Since individuals may play more than one game title at a time, participants were asked to report additional game titles they played, and the amount of time (hours and minutes) they had spent playing each one. The total time from these additional titles were aggregated with time spent playing League of Legends or Teamfight Tactics to represent an

adjusted amount of time spent gaming. All variables included in the final models are represented as hours spent gaming per week.

Gaming Disorder Symptoms

The Gaming Disorder Test-4 (GDT-4) questionnaire was used to evaluate GD (Pontes et al., 2021). The 4 items included in the GDT-4 mirrors those of GD symptomatology in the ICD-11 across five levels (1 = never, 5 = very often), with higher scores indicating higher frequency of exhibiting a symptom. Sample questions of the questionnaire include "I have had difficulties controlling my gaming activity" and "I have continued gaming despite the occurrence of negative consequences." The scope of gaming activities evaluated in the scale was modified from past 12 months to past week to align it with the time frame of the present study. The scale has demonstrated concurrent and discriminant validity, and excellent reliability (Pontes et al., 2021).

Depressive Symptoms

The Depression subscale of the Depression, Anxiety, and Stress Scale-21 (DASS-21) was used to evaluate symptoms of depressive symptoms (Lovibond, 1995). The subscale contains 7 items that assess common symptoms of depression in the past week across 4 levels (0 = Did not apply to me at all, 3 = Applied to me very much or most of the time). Sample questions from the subscale include "I was unable to become enthusiastic about anything" and "I felt that life was meaningless." The scale possesses adequate internal consistency and concurrent validity (Antony et al., 1998). The Depression subscale specifically demonstrated good internal consistency in a nonclinical sample of U.S. adults (Sinclair et al., 2012). It also possesses good internal reliability convergent validity when utilized across other cultures, such as ones within Asian populations (Oei et al., 2013).

Behavioral Activation Levels

The Behavioral Activation for Depression Scale-Short Form (BADS-SF) was used to evaluate behavioral activation levels (Manos et al., 2011). The scale consisted of 9 items that inquiries about individuals' level of behavioral activation within the past week, each across 7 levels (0 = Not at all, 6 = Completely). The items are divided into two subscales, activation and avoidance. The recommended method of combining the two subscales was used in this study due to the small number of items. Sample questions of the scale include "I am content with the amount and types of things I did" and "Most of what I did was to escape from or avoid something unpleasant." The scale possesses acceptable internal consistency reliability, construct validity, and predictive validity (Manos et al., 2011), with good reliability when utilized in non-clinical samples across different cultures (Wagener et al., 2015; Shudo & Yamamoto, 2017).

Analytic Strategy

SPSS version 27.0 was utilized for descriptive and mediation analyses. Specifically, the PROCESS Macro was used to conduct mediation analysis detailed below. Bias-corrected bootstrapping with 1000 bootstrap samples was selected to maximize power to detect mediation and allow for non-normal samples (Preacher & Hayes, 2008; MacKinnon et al., 2007; Fritz & MacKinnon, 2007), such as when including individuals who are highly engaged in video gaming and thus spend a substantially longer amount of time gaming than the majority. Using this modeling technique, simultaneous regression analyses are conducted which generates confidence intervals that correct for bias in estimating indirect effects, which is determined to be statistically significant if zero is not contained within the confidence interval.

Models included assessment of the indirect effects of time spent gaming at T1 (X) on GD at T3 (Y) with behavioral activation levels at T2 set as the mediator (M). These measures for time spent gaming (Model 1 & 2) included objective logged data, self-report estimates, and adjusted

times for both that factored in other games the participants played. Time spent gaming at T1 was then replaced with depressive symptoms at T1 (X) (Model 3). After these initial analyses, variables in all simple mediation models were then controlled for their respective baseline values (GD at T1 and T2, behavioral activation levels at T1) across their respective timepoints to assess if changes in X predicts changes in Y through changes in M. A post-hoc linear regression was also conducted to assess the effect size of the relationship between behavioral activation levels at T2 (X) and GD at T3 (Y). Primary game title (League of Legends or Teamfight Tactics) was used as a covariate across all three timepoints in all the above models to control for game genre. Demographic variables were assessed for significant bivariate relationships with GD, no relationships were found to be significant. Therefore, they were not included as covariates.

Results

Descriptive and Correlations

All demographic characteristics for participants are contained in Table 1. The mean age of the sample is 22.34 (SD = 3.67), with the majority identifying as male (82.7%) and white (66.3%) League of Legends players (64.3%). Most (93.9%) also identified themselves as recreational gamers who mainly engaged in gaming for leisure or socializing with friends. The average difference between objective logged data and subjective self-report is 2.71 hours per week (SD = 8.87). The average absolute difference (examining differences after without consideration for positive or negative bias), was 5.20 (SD = 7.66) hours per week.

All baseline correlations for participants are contained in Table 2. Notably, subjective self-reports on time spent gaming were negatively correlated with behavioral activation levels, and positively correlated with GD and depressive symptoms. Behavioral activation levels were negatively correlated with GD symptoms. Correlations between repeated assessments are contained in Table 3 and ranged from r=.49 to r=.86.

Main Results

Indirect Effects of Time Spent Gaming on GD

The indirect effect of objective logged data of time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 was not significant (B=-.022, SE=.030, 95% CI [-.078 to .039]), though a significant association was observed between behavioral activation levels at week 2 and GD at week 3 (B=-.19, SE=.030, p<.001, 95% CI [-.25 to -.13]). After controlling

for baseline variables across respective timepoints, the indirect effect of objective logged data of time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 remained non-significant, and the previously significant association between behavioral activation levels at week 2 and GD at week 3 was no longer significant.

A significant indirect effect was observed for subjective self-report time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 (B=0.048, SE=.024, 95% CI [0.011 to 0.11]). Individuals reporting more time spent gaming at week 1 also reported lower behavioral activation levels at week 2 (B=-.28, SE=.11, p<.05, 95% CI [-.49 to -.070]), which was in turn associated with increased GD at week 3 (B=-.17, SE=.030, p<.001, 95% CI [-.23 to -.11]). However, this indirect effect became non-significant after controlling for baseline variables across respective timepoints, and the previously significant associations between variables were no longer significant.

Indirect effects of adjusted objective logged data of time spent gaming at week 1 on GD at week 3 through Behavioral Activation at week 2 was not significant (B=-.00010, SE=.014, 95% CI [-.029 to .027]), though a significant association was observed between behavioral activation levels at week 2 and GD at week 3 (B=-.19, SE=.030, p<.001, 95% CI [-.25 to -.13]). After controlling for baseline variables across respective timepoints, the indirect effect of adjusted objective self-report of time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 remained non-significant, and the previously significant association between behavioral activation levels at week 2 and GD at week 3 is no longer significant.

Indirect effects of adjusted subjective self-report of time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 was also not significant (B=.019, SE=.012, 95% CI [-.0011 to .047]), though a significant association was observed between behavioral

activation levels at week 2 and GD at week 3 (B=-.18, SE=.030, p<.001, 95% CI [-.24 to -.12]). After controlling for baseline variables across respective timepoints, the indirect effect of adjusted subjective self-report of time spent gaming at week 1 on GD at week 3 through behavioral activation levels at week 2 remained non-significant, and the previously significant association between behavioral activation levels at week 2 and GD at week 3 is no longer significant.

Indirect Effects of Depressive Symptoms on GD

A significant indirect effect was observed for depressive symptoms at week 1 on GD at week 3 through behavioral activation levels at week 2 (B=0.18, SE=.053, 95% CI [0.077 to 0.29]). Individuals reporting higher depressive symptoms at week 1 also reported lower behavioral activation levels at week 2 (B=-1.08, SE=.16, p<.001, 95% CI [-1.40 to -.76]), which was in turn associated with more severe GD at Week 3 (B=-.17, SE=.035, p<.001, 95% CI [-.24 to -.094]). However, this indirect effect was no longer significant after controlling for baseline variables across respective timepoints, and the previously significant associations between individual variables were also no longer significant.

Discussion

The primary aim of this study was to evaluate whether time spent gaming and depressive symptoms predict symptoms of GD over time and examine whether behavioral activation levels serve as a mediating variable in these relationships. A significant indirect effect was observed between self-reported time spent gaming and GD symptoms via behavioral activation levels. A similar indirect effect was observed between depressive symptoms and GD via behavioral activation levels. This suggests that self-reported time spent gaming and depressive symptoms are indirectly associated with GD symptoms over time, with behavioral activation levels serving as a mediator of the relationship. Behavioral activation levels were also significantly associated with GD in the subsequent timepoint across all models. In order to assess the magnitude of this effect, the direct relationship between behavioral activation level at the second timepoint and GD at the final outcome was assessed. For every 1.8 SD increase in behavioral activation levels at T2, there was a 1 SD decrease in GD symptoms at the final assessment. When all variables were controlled for their baseline values, the longitudinal associations observed were no longer significant. This suggests that changes in subjective self-report of time spent gaming and depressive symptoms observed in a one-week period were not related to variations in GD.

The significant effect of self-reported time spent gaming on GD considered in light of the non-significant effect of objective logged data provides valuable insight to current debates regarding GD that focus on time spent gaming as a variable of interest. The large discrepancies observed (approximately 5 hours per week) between objective logged data and self-report

estimates mirror findings in previous studies on other forms of technology, such as cellphone use (Kahn et al., 2014; Jones-Jang et al., 2020; Sewall et al., 2020). Objective logged data was also the only measurement of time spent gaming that was not significantly correlated with GD. This represents a source of potential systematic bias. Previous research has found that individuals with depressive symptoms overestimate the amount of time they spend using digital media (Sewall & Parry, 2021). This is specifically relevant to the present study, given that a significant correlation was found between self-reported time spent gaming and depressive symptoms at baseline. Moreover, there was a significant correlation between the discrepancy in time spent gaming (self-reported time spent gaming minus logged data) and depressive symptoms. Specifically, a significant positive correlation (r=.26) was observed between the two variables, suggesting that those who exhibited more depressive symptoms also saw greater discrepancies in their reports of time spent gaming. If this trend continues to be observed in future studies, it may indeed imply that associations established between self-reported time spent gaming and GD symptoms are prone to systematic bias. Therefore, results derived from self-reported data on player behavior alone should be interpreted with caution.

While additional research is needed to establish the validity of self-reported time spent gaming, the current study demonstrates a significant relationship between depressive symptoms and GD symptoms. The indirect effect of depressive symptoms on GD over time provides support for the compensatory theory which suggests that individuals who engage in problematic gaming behavior may be doing so to cope with depressive symptoms. Another possible implication of these findings is that previous and current governmental policies that focus on reducing spent gaming alone may be ineffective at preventing GD (Király et al., 2018). Existing research suggests that individuals can and do engage in extended periods of video gaming without significant

detriments to their daily functioning (Griffiths, 2010; Slack et al., 2022). Therefore, future interventions should also address contributing factors to functional impairments associated with GD onset, including depressive symptoms and behavioral activation levels. Nevertheless, it is important to acknowledge that time spent gaming should not be disregarded entirely in future research. It should instead be examined within the context of how it may potentially interfere with other activities that individuals may find personally significant and meaningful to participate in. For example, future studies could examine interventions that target both time spent gaming and behavioral activation levels within a 2x2 factorial design, with control for each active condition. This would provide much needed evidence to better understand the causal relationships between these variables and GD.

This study includes several limitations. While the longitudinal design of this study represents an improvement to cross-sectional designs prevalent in most studies on GD, causal interpretations remain unestablished. The significant results obtained for indirect effects should be interpreted with caution due to potential alpha inflation. Given that bootstrapped mediation analysis does not provide specific p-values for the observed indirect effects, correction for alpha values was not implemented in the current study. No experimental manipulations occurred in this study, meaning that all changes over time were based on variations that occurred naturally. Future research should explore longitudinal designs with other timeframes, such as timepoints spaced several weeks or month apart, to further examine how variations in GD and relevant factors relate to one another. Alternatively, future studies could also include a higher frequency measurement modality such as Ecological Momentary Assessment (EMA). This would allow researchers to capture potential daily fluctuations in GD symptomatology, and their relationship to other variables of interests. Future studies on GD should also explore experimental designs. For instance,

directly targeting participants' Time Spent Gaming could help elucidate the subsequent effect on GD symptoms via temporary moderation or abstinence (King et al., 2018; Brailovskaia et al., 2022). Additionally, the current study utilized a convenience sample of participants who primarily played League of Legends and Teamfight Tactics on the North American server. This decision stems from the practical need to restrict the sample to one in which the researchers had direct access to objective logged data. However, this also limits generalizability of the study results in terms of geographic region and game genre. This limitation may be addressed in the future as more research studies involving direct access to player data and collaboration with video game companies emerge, and as more data on player behavior from various video game titles and platforms become accessible to independent researchers.

In summary, subjective self-report estimates of time spent gaming and depressive symptoms were associated with elevated GD symptoms over time, with behavioral activation levels mediating both relationships. The non-significant results from objective logged data on time spent gaming, along with the significant discrepancy between self-report estimates and logged data highlight that study findings based on self-report estimates alone should be interpreted with caution. When baseline values were factored into the models, all observed effects were no longer significant. This suggests that naturally occurring changes in these variables do not significantly impact gaming disorder symptoms within a one-week time period. Significant associations between behavioral activation levels and GD over time were also observed across the analyzed models. This suggests that behavioral activation levels should be examined as a variable of interest in developing treatments for GD. Important considerations for future research include experimental manipulation to the variables observed to be significantly associated with increased gaming disorder symptoms over time in the current study. Specifically, interventions designed to

target behavioral activation levels as well as time spent gaming will provide highly valuable data that will help to build evidence for causal factors impacting gaming disorder symptoms.

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Table 1. Baseline (T1) participant characteristics (N = 98).

Variable	Mean (SD) % (n)
Age (years)	22.34 (3.67)
Gender	
Male	82.7% (81)
Female	15.3% (15)
Prefer to self-describe	1% (1)
Prefer not to disclose	1% (1)
Race	
White	66.3% (65)
Asian	18.4% (18)
Prefer to self-describe	8.2% (8)
Black or African American	4.1% (4)
Some other race, ethnicity, or origin	2% (2)
Prefer not to say	1% (1)
Gaming Status	
Recreational	93.9% (92)
Professional	6.1% (6)
Objective Logged Time Gaming (hrs/wk)	7.08 (6.20)
Subjective Self-report Time Gaming (hrs/wk)	9.79 (9.18)
Objective Adjusted Time Gaming (hrs/wk)	22.53 (14.04)
Subjective Adjusted Time Gaming (hrs/wk)	25.24 (16.12)
Behavioral Activation Levels (BADS-SF)	31.84 (9.98)
Gaming Disorder Symptoms (GDT-4)	9.78 (3.61)
Depressive Symptoms (DASS-21-D)	5.68 (5.13)

Note: BADS-SF = Behavioral Activation for Depression Scale – Short Form, GDT-4 = Gaming Disorder Test – 4 item. DASS-21-D = Depression Anxiety Stress Scale – 21 – Depression Subscale.

Table 2. Correlations between key variables at baseline (T1)

Variable	1	2	3	4	5	6	7
(1) Objective Logged Time Gaming (hrs/wk)	1						
(2) Subjective Self-report Time Gaming (hrs/wk)	.387**	1					
(3) Objective Adjusted Time Gaming (hrs/wk)	.255*	.111	1				
(4) Subjective Adjusted Time Gaming (hrs/wk)	.058	.517**	.836**	1			
(5) Behavioral Activation Levels (BADS-SF)	-.001	-.344**	-.121	-.301**	1		
(6) Gaming Disorder Symptoms (GDT-4)	-.027	.297**	.338**	.473**	-.467**	1	
(7) Depressive Symptoms (DASS-21-D)	-.044	.220*	.122	.248*	-.683**	.435**	1

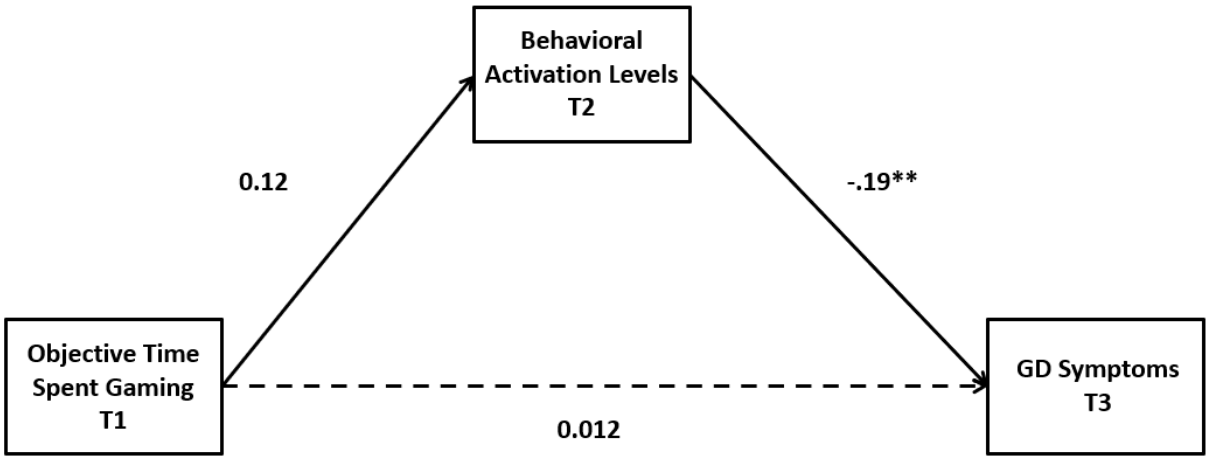
Note: BADS-SF = Behavioral Activation for Depression Scale – Short Form, GDT-4 = Gaming Disorder Test – 4. DASS-21-D = Depression Anxiety Stress Scale – 21 – Depression Subscale.

Table 3. Correlations between repeated measures at baseline and follow-ups

Variable	T1-T2	T1-T3
Objective Logged Time Gaming (hrs/wk)	r=.64**	r=.49**
Subjective Self-report Time Gaming (hrs/wk)	r=.75**	r=.64**
Objective Adjusted Time Gaming (hrs/wk)	r=.64**	r=.61**
Subjective Adjusted Time Gaming (hrs/wk)	r=.67**	r=.64**
Behavioral Activation Levels (BADS-SF)	r=.78**	r=.79**
Gaming Disorder Symptoms (GDT-4)	r=.76**	r=.59**
Depressive Symptoms (DASS-21-D)	r=.86**	r=.84**

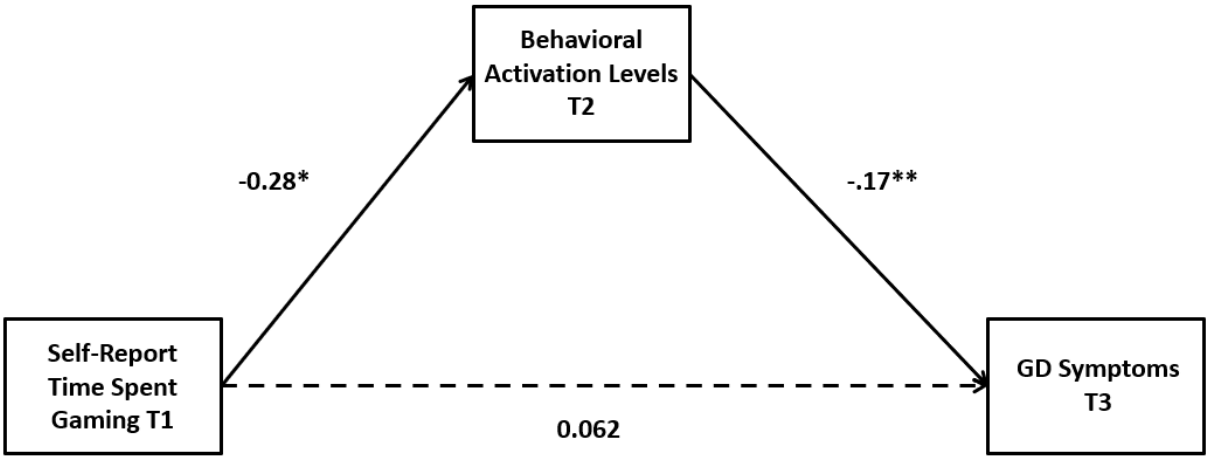
Note: BADS-SF = Behavioral Activation for Depression Scale – Short Form, GDT-4 = Gaming Disorder Test – 4. DASS-21-D = Depression Anxiety Stress Scale – 21 – Depression Subscale.

Figure 1. Objective time spent gaming on GD via behavioral activation levels



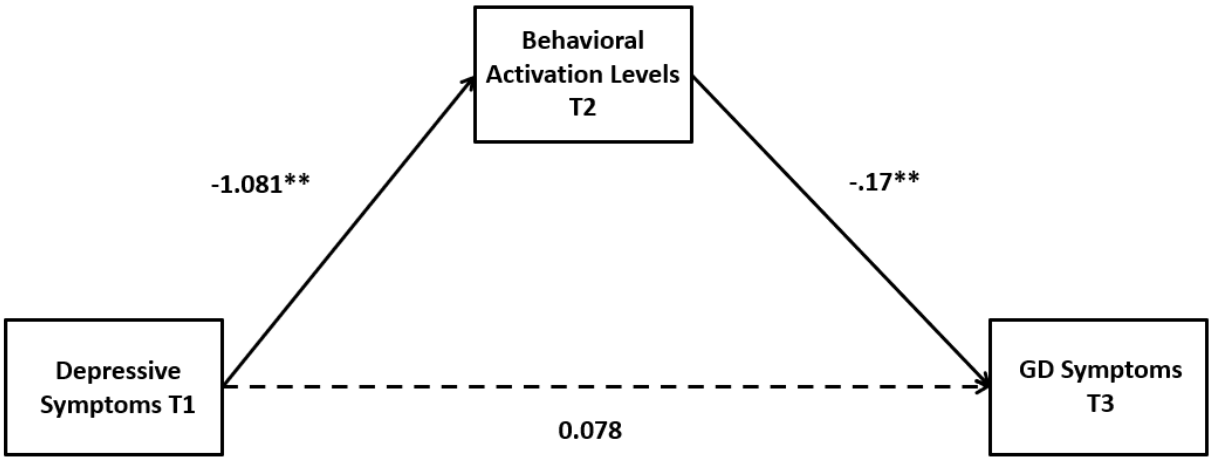
Model 1:
The indirect effect of objective time spent gaming on GD through behavioral activation levels was not significant (B=-.022, SE=.03, 95% CI [-.078 to .039]).
* = p<.05
** = p<.01

Figure 2. Self-report time spent gaming on GD via behavioral activation levels



Model 2:
The indirect effect of self-report time spent gaming on GD through behavioral activation levels was significant (B=0.048, SE=.024, 95% CI [0.011 to 0.11]).
* = p<.05
** = p<.01

Figure 3. Depressive symptoms on GD via behavioral activation levels



Model 3:
The indirect effect of depressive symptoms on GD through behavioral activation levels was significant (B=0.18*, SE=.053, 95% CI [0.077 to 0.29]).
* = p<.05
** = p<.01