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Sex differences in ADHD symptoms, problematic gaming, and impairment in college students

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Abstract

Objective: ADHD is associated with impairment in several important areas of life for college students, including lower grades and lower degree completion rates. Further, college students with ADHD may be involved in higher levels of problematic gaming than their peers, conveying incremental impairment. Therefore, the aim of the current study was to examine whether problematic gaming is associated with impairment in the context of elevated ADHD symptoms in college students, with a focus on possible sex differences. **Method:** College students ($N = 1{,}489$; $M_{age} = 19.13$, 69.4% female, 86.7% white) from three universities completed an online survey assessing ADHD symptoms, problematic gaming, and functional impairment. **Results:** There was a significant 3-way interaction among inattention symptoms, problematic gaming, and sex on impairment, such that impairment was greatest among female college students high in inattention (IA) and problematic gaming. There was not a significant 3-way interaction that included hyperactivity/impulsivity (HI) symptoms, but significant 2-way interactions indicated that women who game experience more impairment than men who game, and that when gaming is added to elevated HI, impairment increases significantly. **Conclusions:** Our data suggest that problematic gaming by college students with elevated ADHD symptoms might lead to additional impairment, especially in women. We discuss clinical implications such as a potential problematic gaming module for college ADHD treatments, and a harm-reduction approach to gaming in this population.

Keywords ADHD · College · Adult · Gaming · Internet gaming disorder · sex/gender · Impairment

Attention-deficit/hyperactivity disorder (ADHD) is defined by the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision* (*DSM-5-TR*; American Psychiatric Association [APA], 2022) as the presence of persistent, age-inappropriate inattention (IA) and/or hyperactivity/impulsivity (HI) symptoms. Increasingly, researchers have focused their attention on the manifestation of ADHD in adulthood (Barkley, 2015; Barkley et al., 2008). In particular, emerging adults (i.e., 18–25 years; Arnett, 2000) with ADHD who are enrolled in college face unique challenges given the organizational, time management, and planning demands of higher education (Barkley, 2015; Kwon et al., 2018; Lefler et al., 2016). Impairment in college students with ADHD includes poorer work performance (Shifrin et al., 2010) and social skills, low self-esteem (Shaw-Zirt et al., 2005), increased risky sexual behavior (Huggins et al., 2015), higher rates of negative alcohol-related outcomes and risky driving (Reimer et al., 2005), more difficulty with financial management (Altszuler et al., 2016), higher psychological distress (Weyandt et al., 2013), poorer academic performance (DuPaul et al., 2021), lower university degree completion rates (Weiss & Hechtman, 1993), and more often needing to repeat a class (Barkley, 2015) compared to non-ADHD peers. One relatively recent phenomenon that has been linked to ADHD is problematic gaming.

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Problematic gaming

Problematic computer, internet, or video gaming has been referred to in the literature by many names: internet addiction, video game addiction, computer game misuse, addictive gaming, pathological video-game use, gaming disorder, and internet gaming disorder (IGD). In the current paper, we will generally refer to this phenomenon using the umbrella term *problematic gaming*, but at times we will also use the potential diagnostic category *IGD*. The *DSM-5-TR* has yet to officially classify this as a diagnosis; rather, it lists IGD in the *Conditions for Further Study* section of the manual (APA, 2022). Proposed symptoms of IGD in *DSM-5-TR* include "unsuccessful attempts to control the participation in internet games" and "use of internet games to escape or relieve a negative mood" (APA, 2022, p. 913–914). King and colleagues (2018) argued that problematic gaming should qualify as a mental health diagnosis as: (a) it is similar to other addictive behavioral disorders already codified by the *DSM* (e.g., Gambling Disorder), (b) there is evidence that clinically problematic gaming is separate from typical gaming, (c) the associated functional impairment of losing control over gaming is significant, and (d) there is often a need for a diagnostic label to obtain health insurance coverage for treatment.

Prevalence estimates of disordered gaming range from 1.2% in Swedish teens and adults (ages 15 years+; André et al., 2020), 3.7% in German teens and adults (ages 14 years+; Festl et al., 2013), 4.7% in young adults in the United Arab Emirates (Vally, 2021), and up to 8% in adolescents in the United States (US; Gentile et al., 2009). Thus, prevalence estimates vary depending on the definition of gaming symptoms, study methodology, and sample characteristics. Nonetheless, prevalence rates of up to 8% represent a sizable group of affected individuals.

Like ADHD, problematic gaming has been linked to functional impairment in some studies. For instance, problematic gaming or the broader "internet addiction" has been associated with poor academic performance in adolescents (Hawi et al., 2018; Jiang, 2013) and adults (Ko et al., 2009), and individuals with elevated IGD symptoms reported engaging in more unhealthy behaviors (e.g., poor nutrition and sleep habits; Hawi et al., 2018; Ko et al., 2009). However, in another study, IGD symptoms were associated with lower levels of anxiety, as gaming was hypothesized to distract children and adolescents from rumination and negative affect (Hygen et al., 2020). Thus, more research regarding impairment and problematic gaming is warranted, especially in the context of ADHD, and with a consideration of sex.

Sex, ADHD, and problematic gaming

In the study of mental illness, including ADHD and the potential diagnostic category of IGD, it is important to avoid sex- and gender-neutral research (Howard et al., 2017). Sex- and gender-neutral research occurs when researchers ignore or minimize the impact of the sex and/or gender of their participants, and perhaps mistakenly assume their data are widely generalizable. Thus, many authors (Cahill, 2010; Hartung & Lefler, 2019; Heidari et al., 2015; Rutter et al., 2003; Zahn-Waxler et al., 2008) have called for the careful examination of sex and/or gender so we can better understand psychopathology, make more accurate diagnoses, and better tailor treatments to individuals. We work to avoid the problem of sex- and gender-neutral research in the current study of ADHD symptoms and problematic gaming.

The relation between ADHD and problematic gaming in children, adolescents, and emerging adults has received some research attention. In very young children (i.e., M_{age} = 5.8 years), those with clinically significant ADHD are particularly susceptible to problematic gaming habits (Paulus et al., 2018), and notable sex differences emerged with IA predicting problematic gaming for girls and HI predicting problematic gaming for boys. Similarly, in a nationally representative survey of over 1,100 8- to 18-year olds (50% males), Gentile (2009) found that 8.5% of children and adolescents who play video games satisfy the proposed diagnostic criteria for IGD, and that 25.3% of children and adolescents who qualified for IGD had an ADHD diagnosis. Conversely, Frolich and colleagues (2016) did not find a relation between ADHD and problematic gaming in a clinical sample of adolescents (M_{age} = 15 years; 62% male). Likewise, in a study of 700 youth ages 10–14 years (52% females), the authors found that while group-level correlations between IGD and ADHD were significant, at the within-person level, the concurrent correlation was not significant (Hygen et al., 2020). Thus, findings are mixed in terms of the relation between ADHD and problematic gaming in youth.

The research on ADHD and problematic gaming in emerging adults shows a more consistent pattern. For example, in a study of 2,500 college students, Yen and colleagues (2009) found that screening positive for ADHD symptoms (particularly IA) was associated with problematic gaming, and this association was significantly stronger among female college students. Moreover, in another study of college students (60% females), Evren et al. (2018) found that the association between problematic gaming and self-reported ADHD symptoms was still present after controlling for negative affect (i.e., symptoms of anxiety and depression), emotion dysregulation, and neuroticism. In addition, in a study of 1,200 + participants (M_{age} = 20.32 years; 50% females),

Stockdale and Coyne (2018) found that those who exhibit problematic gaming (i.e., 7% of the sample) had more self-reported ADHD symptoms than typical video game players, regardless of sex. Other studies have similarly demonstrated a link between ADHD symptoms and problematic gaming among both male and female emerging adults (e.g., Dullur et al., 2021; Mathews et al., 2019; Panagiotidi, 2017; Pearcy et al., 2017; Stavropoulos et al., 2020; Vally, 2021).

Finally, Lee and colleagues (2021) found that individuals with IGD and ADHD had worse clinical outcomes (i.e., severity, recurrence) and impairment over a three-year period compared to individuals with IGD alone. In fact, they found that as ADHD symptoms improved, IGD symptoms also improved. Participants in this study ranged from age 11 through adulthood, and sex/gender was not included as a primary variable. This might suggest that problematic gaming alone is not as impairing as problematic gaming paired with ADHD symptoms, but more research is needed regarding sex differences and in the college student population specifically.

In sum, problematic gaming seems to be linked to ADHD in emerging adult college students, but more research is needed regarding the relations among ADHD, problematic gaming, impairment, and sex. Thus, among a large sample of college students, we hypothesized that problematic gaming, moderated by IA (Hypothesis 1) or HI (Hypothesis 2) and sex, would predict impairment.

Method

Participants

Participants included 1,489 students (M_{age} = 19.13 years, SD = 1.36; 77.0% in their first or second year of college) across three universities in the Rocky Mountain, Midwest, and Mid-Atlantic regions of the US. Inclusion criteria were current enrollment in college and age of 18 to 25 years. Regarding biological sex or sex assigned at birth, 69.4% of the participants identified as female, 30.6% as male, and no participant identified as intersex; and as for gender identity, 68.9% of the participants identified as women, 30.4% as men, and 0.7% as transgender or non-binary. Participants identified as 86.7% White, 4.7% Hispanic/Latino, 3.8% African American, 2.6% Asian/Asian American, 1.0% American Indian or Pacific Islander, and 1.1% preferred not to answer. Regarding sexual orientation, 88.5% of the sample identified as heterosexual/straight. Finally, 50.9% of the participants reported playing video games, and 9.2% reported a diagnosis of ADHD at some point in their life.

Procedures

Institutional review board (IRB) approval was obtained for this multisite study of ADHD symptoms in college students (i.e., the Undergraduate Learning, Emotion, and Attention Research Network [U-LEARN] study). Undergraduate students across the universities were recruited via online participant management sites (i.e., SONA). The survey was hosted on a secure online survey platform (i.e., Qualtrics), through which participants first gave their informed consent to participate, and then completed a series of measures that were delivered in a counterbalanced manner. Although participants completed a variety of measures for the larger U-LEARN project, only measures relevant to the current study are described here. Participants were compensated with research credits for study participation.

Measures

Demographics form Participants reported their sex, gender identity, sexual orientation, age, race/ethnicity, and other demographic information.

***DSM-5*ADHD Current Symptoms Checklist (APA**, 2013): A self-report checklist was created based on the exact wording of ADHD symptoms in the *DSM-5* (APA, 2013). The *DSM-5* symptoms used in the current study are identical to those in the newer *DSM-5-TR* (APA, 2022). Participants rated their current ADHD symptoms using this scale: 0 (*Never/Rarely*), 1 (*Sometimes*), 2 (*Often*), or 3 (*Very Often*). Severity scores, ranging from 0 to 27, were created for each participant for the two ADHD symptom dimensions (i.e., IA and HI). In the current study, internal consistency reliability for IA was excellent ($\alpha = 0.93$), and for HI was good ($\alpha = 0.87$).

Revised Video Game Addiction (VGA) Questionnaire (Gentile, 2009**)**: The Revised VGA questionnaire is a 16-item scale updated from Gentile (2009) and Gentile et al. (2011). Item 1 refers to frequency of video game use, and for items 2–16 participants respond using the following scale: 1 (*Yes*), 2 (*No*), 3 (*Sometimes*), or 4 (*Don't know*), with *Yes* responses scored as 1 point, *Sometimes* responses scored as 0.5 points, and *No* and *Don't know* responses scored as 0 points (Gentile, 2009). An example item is "Have you ever felt you could not stop playing video games?" A sum score was created for each participant. The VGA was modeled after proposed *DSM* symptoms of pathological gambling. In the current study, internal consistency reliability was excellent ($\alpha = 0.90$).

Weiss Functional Impairment Rating Scale (Weiss, 2000**)**: The Weiss Functional Impairment Rating Scale (WFIRS) is a 70-item self-report measure of impairment in 7 domains of life (i.e., family, work, school, life skills,

self-concept, social, and risk). Participants rate whether or not they experience impairment on the following 4-point scale: 0 (*Never or Not at all*), 1 (*Sometimes or Somewhat*), 2 (*Often or Much)*, or 3 (*Very often or Very much*). Participants who are not employed have the option to select *Not Applicable* for all items on the work domain. When calculating an overall impairment score for the current study, 142 participants rated the work domain as not applicable, so the overall WFIRS average for these participants does not include work-related impairment. An overall impairment mean was calculated by summing all items with a response and dividing by the number of items completed, and a similar strategy was used for each of the 7 domains (i.e., an average of all completed items). The WFIRS has been shown to be a good measure of impairment in college students (Canu et al., 2020), with excellent internal consistency reliability in past studies (Hartung et al., 2016). In the current study, internal consistency reliability was excellent for overall impairment ($\alpha = 0.95$) and ranged from good to excellent (0.82 to 0.94) for the 7 individual domains.

Results

Data Analytic Plan and Data Preparation

Data were analyzed using SPSS Version 24, with the Process Macro Version 3.5.3 (Hayes, 2018). For the preliminary analyses, independent samples *t*-tests were conducted to examine sex differences on the variables of interest, and then bivariate correlations were conducted to examine the relations among all variables; first, for the entire sample, and then separately based on sex. Comparisons of correlations were examined for statistically significant differences via an online statistics calculator. Given that sex differences were of primary interest in this study, references to *men* and *women* throughout this paper are based on biological sex or sex assigned at birth (not gender identity).

As stated previously, we hypothesized that problematic gaming, moderated by IA (Hypothesis 1) or HI (Hypothesis 2) and sex, would predict impairment. To test these hypotheses, two moderated moderation regression analyses were conducted via Process Model 3 (i.e., one with IA and the other with HI). In these analyses, gaming was entered as the dependent variable, IA or HI and sex were the moderators, and overall impairment was the independent variable. In the Process analyses, the level of confidence was set at 95% and 5000 bootstrap samples were employed. Tests of simple slopes were conducted to probe any significant interactions, and comparisons of simple slopes were examined for statistically significant differences via an online statistics calculator. Figures depicting simple slope analysis results used the mean (average), one SD above the mean (high), and one SD below the mean (low).

Table 1 *Means (SD) of and Bivariate Correlations between All Primary Variables*

Variable	1	2	3	4
1. IA	5.39 (5.80)			
2. HI	0.75*	3.74 (4.46)		
3. Gaming	0.16*	0.10*	0.91 (2.10)	
4. Impairment	0.71*	0.61*	0.24*	0.42 (0.35)

Note: * $p < .001$. Mean (SD) values on the diagonal; all other values are bivariate correlations. IA = Inattention severity score. HI = Hyperactivity/Impulsivity severity score. Gaming = Problematic gaming score. Impairment = Impairment mean

Prior to analyses, we screened for missing data. Participants who skipped a measure included in the analyses were excluded from the sample. If participants had only minimal (i.e., 1 or 2) missing items for a measure, mean substitution was used. Twenty-two participants were removed as they were outside of the age range for inclusion in the study (i.e., age 26 years or older), and 2 participants did not complete the gaming measure; this resulted in our final analytic sample of 1,489 participants. Outliers were retained as high scores on our measures are of particular interest (i.e., elevated ADHD and gaming). Our sample was adequately powered to detect small effects per a G*Power analysis (i.e., 863 participants needed; Faul et al., 2007).

Preliminary analyses

Based on independent samples *t*-tests, men and women were not significantly different from one another on IA severity scores, HI severity scores, nor overall impairment. However, for problematic gaming, men ($M = 2.20$) scored significantly higher than women ($M = 0.35$), $t\ (1487) = 17.18$, $p < .001$.

Next, bivariate correlations (Table 1) indicated that both IA and HI were significantly and positively correlated with gaming (small effects). Follow-up analyses demonstrated that the IA-gaming correlation was significantly larger than the HI-gaming correlation ($p = .048$), such that that inattention is more strongly linked to problematic gaming. Next, IA and HI were significantly and positively correlated with impairment (large effects). Finally, gaming and impairment were significantly and positively correlated (small effect). Follow-up analyses also demonstrated that the IA-impairment correlation and the HI-impairment correlation were both significantly larger than the gaming-impairment correlation (both $p < .001$), suggesting that ADHD symptoms are more strongly linked with impairment than gaming. We

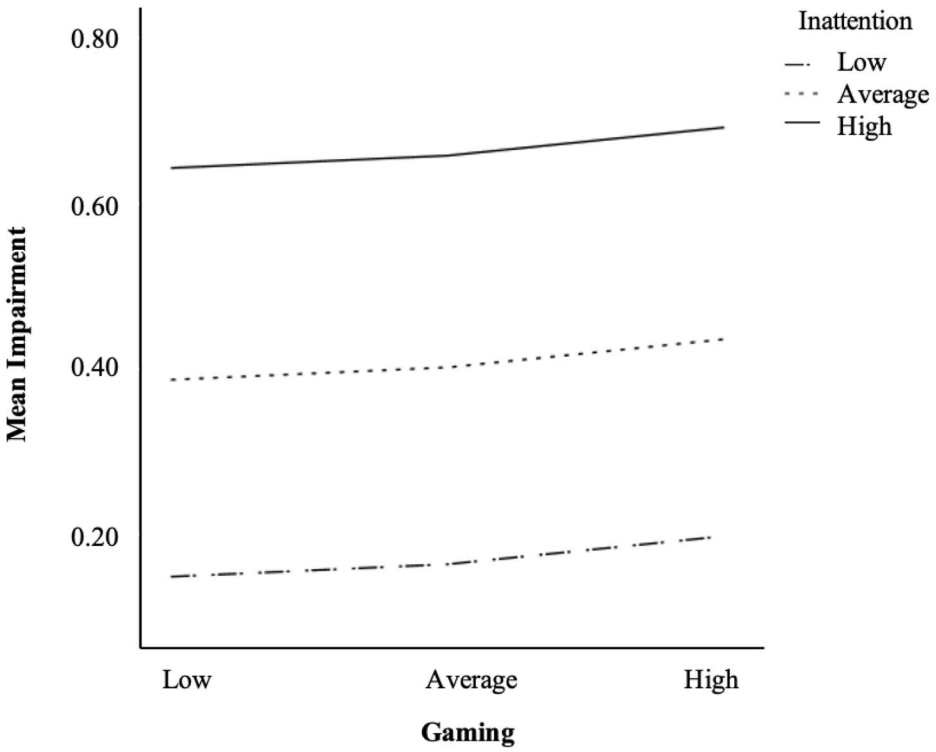

Fig. 1 *Impairment Means for Men by Inattention and Gaming. Note.* With Fig. 2, represents the significant 3-way interaction from hypothesis 1

ran all correlations separately for men and women, and each remained significant in the same direction (data disaggregated by sex available upon request).

Third, because the relation between problematic gaming and impairment is less well established, and because IGD is a proposed *DSM* category, bivariate correlations were also conducted to examine the association between gaming and the seven impairment sub-categories (i.e., family, work, school, life skills, self-concept, social, and risk). Problematic gaming was significantly positively correlated with all seven individual impairment domains: family ($r = .12$, $p < .001$), work ($r = .21$, $p < .001$), school ($r = .22$, $p < .001$), life skills ($r = .23$, $p < .001$), self-concept ($r = .13$, $p < .001$), social ($r = .22$, $p < .001$), and risk ($r = .17$, $p < .001$). These were all small effects (i.e., < 0.30). We ran these bivariate correlations separately for men and women, and all correlations remained significant in the same direction (data disaggregated by sex available upon request).

Primary analyses

Hypothesis 1 The first hypothesis was that problematic gaming, moderated by IA and sex, would predict impairment. To test this, a moderated moderation regression analysis was conducted via Process Model 3. This hypothesis was supported. Specifically, the full model was significant, F (7, 1481) = 238.48, $p < .001$, $R^2 = 0.53$. The main effects of gaming ($B = 0.016$, t (1481) = 2.62, $p < .001$) and IA ($B = 0.044$, t (1481) = 16.94, $p < .001$) were significant predictors of impairment, but sex ($B = 0.039$, t (1481) = 1.79, $p = .073$) was not. The 3-way interaction between IA, gaming, and sex was significant in predicting impairment, ($B = 0.003$, t (1481) = 2.35, $p = .019$). This significant 3-way interaction suggested that for both men and women, impairment was highest when IA was high. However, for women the addition of gaming to IA symptoms increased impairment, whereas for men the addition of gaming to IA symptoms did not have much of an impact (see Figs. 1 and 2).

The tests of simple slopes in this significant 3-way interaction revealed that for men with high inattention ($B = 0.02$, t (1481) = 3.43, $p < .001$, $LLCI = 0.007$, $ULCI = 0.025$), women with high inattention ($B = 0.05$, t (1481) = 8.22, $p < .001$, $LLCI = 0.039$, $ULCI = 0.063$), men with average inattention ($B = 0.02$, t (1481) = 3.84, $p < .001$, $LLCI = 0.008$, $ULCI = 0.024$), women with average inattention ($B = 0.04$, t (1481) = 4.78, $p < .001$, $LLCI = 0.021$, $ULCI = 0.050$), and men with low inattention ($B = 0.02$, t (1481) = 2.62, $p = .009$, $LLCI = 0.004$, $ULCI = 0.028$) the simple slopes were significant. The one exception was that for women with low inattention, the simple slope was non-significant ($B = 0.02$, t (1481) = 1.90, $p = .058$, $LLCI = -0.001$, $ULCI = 0.043$). The slopes for men and women with low inattention were not significantly different from one another (t (1485) = 0.40, $p = .690$); but the slopes for men and women at average (t (1485) = 2.36, $p = .019$) and high (t (1485) = 4.48, $p < .001$)

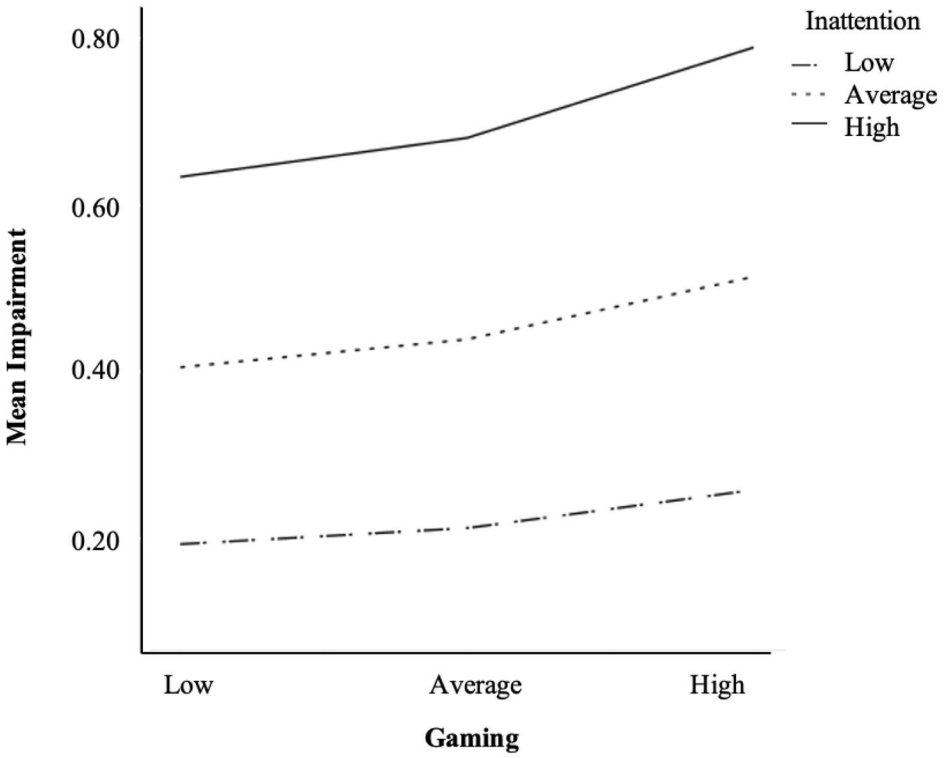

Fig. 2 *Impairment Means for Women by Inattention and Gaming. Note*. With Fig. 1, represents the significant 3-way interaction from hypothesis 1

levels of inattention were significantly different from one another.

Hypothesis 2 The second hypothesis was that problematic gaming, moderated by HI and sex, would predict impairment. To test this, a second moderated moderation regression analysis was conducted. This hypothesis was partially supported. Specifically, the full model was significant, F (7, 1481) = 149.92, $p < .001$, $R^2 = 0.41$. The main effects of gaming ($B = 0.021$, t (1481) = 3.28, $p = .001$), HI ($B = 0.050$, t (1481) = 13.68, $p < .001$), and sex ($B = 0.048$, t (1481) = 2.07, $p = .039$) were all significant predictors of impairment. However, the 3-way interaction was not significant ($B = 0.000$, t (1481) = 0.17, $p = .866$).

Thus, the model was respecified to only include the 2-way interactions (i.e., to take out the variance accounted for by the non-significant 3-way interaction; respecified via Process Model 1). At this point, all three 2-way interactions were significant. Specifically, the 2-way interaction between gaming and sex was significant, $B = 0.046$, t (1481) = 2.37, $p < .001$, such that impairment increased more notably in women with elevated gaming as compared to men with elevated gaming (Fig. 3). Tests of simple slopes revealed that for both men ($B = 0.04$, t (1481) = 6.48, $p < .001$, $LLCI = 0.025$, $ULCI = 0.046$) and women ($B = 0.08$, t (1481) = 9.72, $p < .001$, $LLCI = 0.065$, $ULCI = 0.097$) the slopes were significant. Next, the 2-way interaction between HI and sex was significant, B = -0.009, t (1481) = -2.33, $p = .020$, such that HI was more strongly related to increased impairment in college men than women. Tests of simple slopes revealed that for both men ($B = 0.05$, t (1481) = 17.36, $p < .001$, $LLCI = 0.048$, $ULCI = 0.060$) and women ($B = 0.05$, t (1481) = 23.77, $p < .001$, $LLCI = 0.042$, $ULCI = 0.049$) the slopes were significant. Finally, the 2-way interaction between gaming and HI was significant, $B = 0.002$, t (1481) = 2.37, $p = .018$, such that high HI was associated with the highest levels of impairment, but high gaming increased impairment further (Fig. 4). Tests of simple slopes revealed that at low ($B = 0.022$, t (1481) = 4.49, $p < .001$, $LLCI = 0.013$, $ULCI = 0.032$), medium ($B = 0.028$, t (1481) = 7.93, $p < .001$, $LLCI = 0.021$, $ULCI = 0.035$), and high ($B = 0.035$, t (1481) = 9.16, $p < .001$, $LLCI = 0.028$, $ULCI = 0.043$) levels of HI the slopes were significant, but only the low HI slope and the high HI slope were significantly different from one another (t (1485) = 2.30, $p = .022$).

Discussion

While it is known that ADHD symptoms are associated with impairment, less research has examined problematic gaming-related impairment, whether impairment may be exacerbated by the combination of ADHD symptoms and problematic gaming, and whether sex moderates this

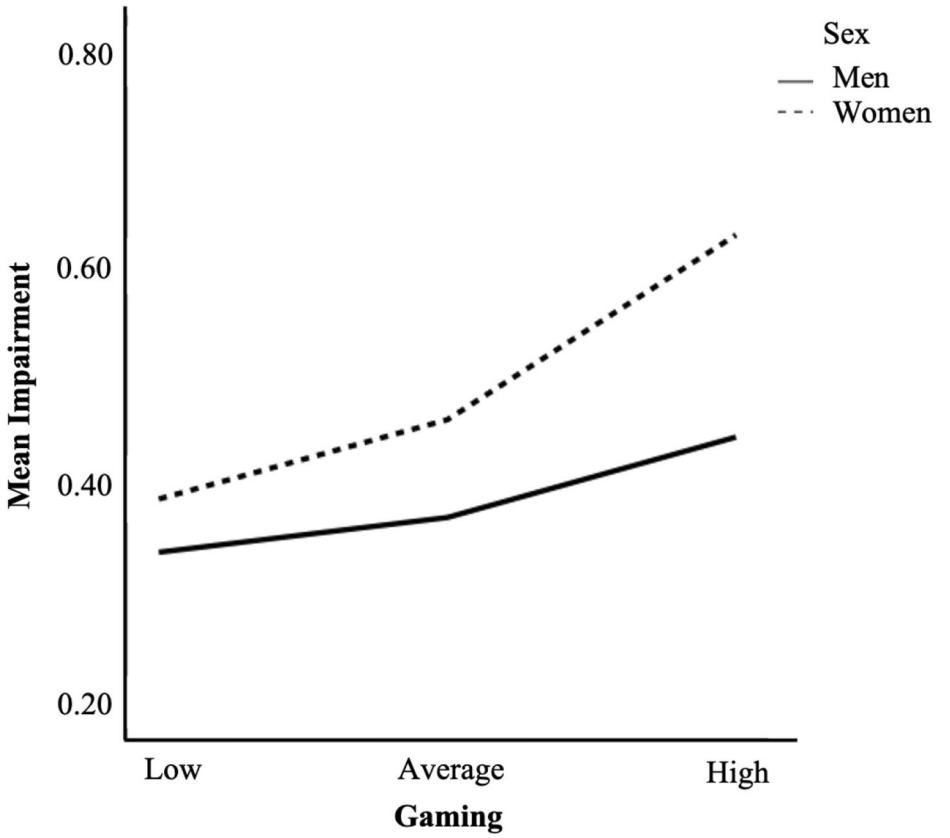

Fig. 3 *Impairment Means for Men and Women by Level of Problematic Gaming. Note*. Represents a significant 2-way interaction from hypothesis 2

relation in college students. Thus, in the current study we set out to examine the relations among ADHD symptom clusters, problematic gaming, impairment, and sex. Our results yielded important differences by sex and ADHD

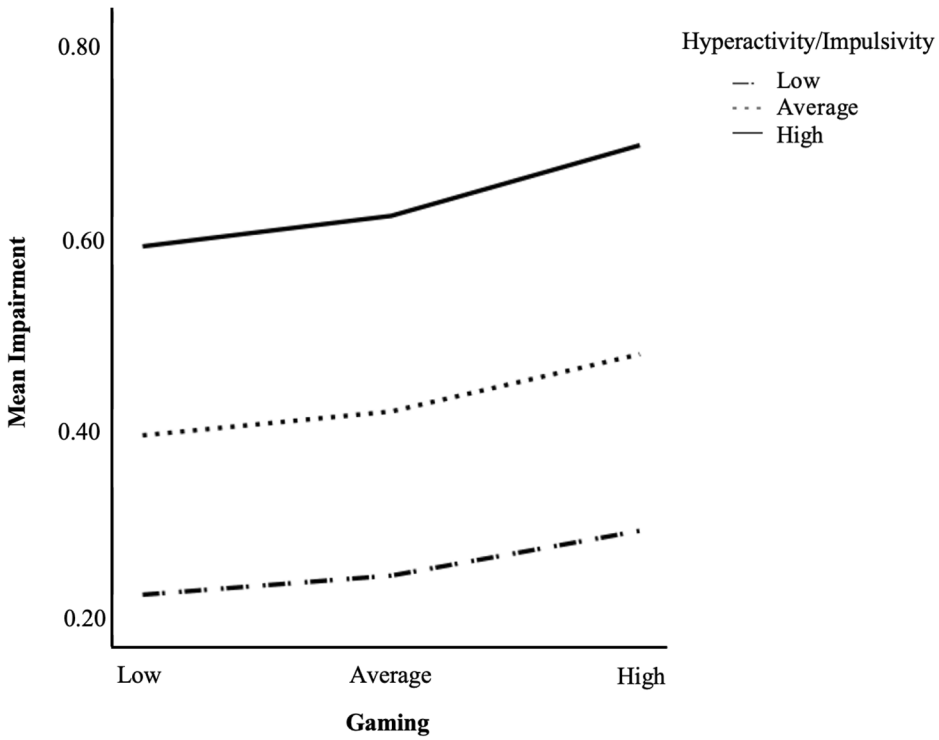

Fig. 4 *Impairment Means by Hyperactivity/Impulsivity and Gaming. Note*. Represents a significant 2-way interaction from hypothesis 2

symptom clusters that inform both clinical intervention and conceptualization of internet gaming disorder (IGD) as a diagnostic category.

In our preliminary analyses, we found that college men have higher rates of problematic gaming than college women. This finding is consistent with past research showing that men and boys engage in increased rates of problematic gaming (APA, 2022; Desai et al., 2010) compared to women and girls. Interestingly, sex differences did not emerge for either IA or HI symptoms.

In another preliminary analysis, we found that IGD symptoms were correlated with all seven subscales of our impairment measure, suggesting that problematic gaming is indeed associated with impairment in several life domains (i.e., family, work, school, life skills, self-concept, social, and risk). However, all correlations between gaming and impairment were small (i.e., < 0.30). This extends the research on the link between problematic gaming and impairment as it encompasses new areas of impairment linked to gaming (e.g., family, self-concept, risk). However, the correlations between gaming and impairment were significantly smaller than the correlations between each ADHD symptom dimension and impairment, suggesting that IGD as a stand-alone diagnosis is not as strongly associated with impairment as IA and HI. Given that impairment is a key aspect of psychopathology diagnoses, more research is warranted to examine whether IGD accounts for enough unique variance in impairment to be considered a disorder.

The results of the primary regression analyses (i.e., the moderated moderations; testing hypotheses 1 and 2) were novel. First, for Regression 1 (with IA and sex as moderators of the association between problematic gaming and impairment), the 3-way interaction was significant. Specifically, we found that for both college men and women, IA symptoms were the primary driver of impairment, but for women, when elevated problematic gaming was combined with elevated inattention, impairment increased significantly more than for men. These findings are interesting given that men endorsed higher levels of problematic gaming than women, but in women with high inattention and high gaming, impairment is especially high. Overall this suggests that IA symptoms accounted for significantly more unique variance in impairment than gaming, and thus it is possible that gaming only leads to problematic outcomes in the context of another impairing disorder. These findings also suggest that college women with ADHD are particularly susceptible to gaming-related impairment, as gaming did not result in increased impairment in men beyond that predicted by IA to the same degree that it did for women. This finding is consistent with that of Wang et al. (2019) who found that, despite the male preponderance in gaming, women might be particularly vulnerable to disordered gaming.

For Regression 2 (with HI and sex as moderators of the association between problematic gaming and impairment), the 3-way interaction was non-significant, so the model was respecified to test the 2-way interactions. All three 2-way interactions (i.e., HI-sex, gaming-sex, and HI-gaming) were significant. These interactions showed that gaming was associated with impairment in both men and women, but women who game experienced more impairment than men who game (regardless of HI). In addition, HI was associated with impairment, and when elevated gaming was added, impairment significantly increased. This is essentially the same pattern as with IA (i.e., Regression 1), except that the full 3-way interaction with HI was non-significant. Overall, across all analyses examined, college women with ADHD seemed to be particularly susceptible to gaming-related impairment.

Taken together, gaming was correlated with several types of impairment, but when examined more closely in the regression analyses, it was clear that IA symptoms accounted for much more variance in impairment than gaming. Moreover, for women with IA symptoms, elevated problematic gaming increased impairment, but IA is still the primary source of variance. This extends the gaming research to show that although problematic gaming is correlated with impairment, it is not the primary driver of impairment when IA is also present. Indeed, Lee et al. (2021) found that when ADHD was effectively treated, problematic gaming was also reduced. This might suggest that problematic gaming is secondary to ADHD symptoms. However, as Stavropoulos et al. (2019) noted, there is likely a bi-directional relation between ADHD and gaming such that ADHD leads to increased problematic gaming, and problematic gaming exacerbates ADHD-related impairment.

King et al. (2018) have argued that IGD should qualify as a *DSM* diagnosis, in part because the associated functional impairment of losing control over gaming is significant. However, the findings herein suggest that because problematic gaming does not predict near the level of impairment as IA, IGD-related impairment may not rise to the level of clinically significant, and therefore not to the level of an independent diagnosis, particularly in the absence of another mental health concern (e.g., ADHD or possibly anxiety or depression). Nevertheless, King et al. (2018) went on to argue that IGD should be a unique diagnosis because it is similar to other addictive behavioral disorders, is separate from typical gaming, and for insurance coverage of treatment (King et al., 2018). Our findings cannot speak to these other factors; however, we did find that gaming is not as strongly associated with impairment as ADHD. More research is certainly warranted.

Clinical implications

The sample used in the current study was non-clinical; nevertheless, there are clinical implications. For instance, the pattern of overlap between ADHD symptoms, problematic gaming, and impairment might inform clinicians working with college students with ADHD. Specifically, a clinician working in a university setting (e.g., a university counseling center) may find it useful to know that for female clients in particular, frequent video gaming on top of ADHD symptoms can exacerbate impairment. A university counselor might be focused on more common concerns in college students with ADHD such as time management, study skills, and organization (Eddy et al., 2021; Hartung et al., 2020), and may overlook the issue of problematic gaming, especially in young women. Although we found that women engage in lower levels of problematic gaming than men, when women with IA symptoms do engage in gaming, their impairment increases significantly more than for men. It is unlikely that problematic gaming comes up frequently in counseling or psychotherapy; this study offers evidence that clinicians should ask clients with ADHD, particularly their college-aged female clients with elevated IA symptoms, about their gaming habits. This might allow the clinician to catch this additional area of concern, which might lead to earlier intervention and a curtailment of subsequent problems.

It is important to consider that problematic gaming might not be the cause of this additional impairment for women with ADHD (as we cannot speak to causality in our data). That is, it is possible that managing one's time more effectively would reduce the overall time spent gaming, which in turn would in turn reduce impairment. Another possibility is that a person with ADHD might be using gaming as a coping strategy to deal with stress, social relationship difficulties, anxiety/depression, or other problems related to the diagnosis of ADHD. It is well established that individuals with ADHD have trouble with time management, transitioning between tasks, and adaptive coping (Barkley, 2015); perhaps problematic gaming is an outcome of these deficits; or another type of impairment in college students with ADHD.

Regardless of whether gaming causes impairment or is a type of impairment, a modular CBT approach to the treatment of ADHD in college students (LaCount et al., 2015; Safren et al., 2005) could be useful. In modular CBT (Chorpita, 2007), clinicians have more flexibility compared to the traditional manualized treatment approaches such that they have the ability to choose from various modules to suit the individual's specific needs. In ADHD treatments, a module specific to problematic gaming might be a welcome addition. The clinician should of course tease apart whether the gaming is separate from or an outcome of the ADHD, and make treatment plans accordingly. For example, if gaming is being used as a coping strategy for elevated anxiety, a module on anxiety reduction might be most appropriate; whereas if the gaming is judged to be problematic on its own, a gaming-specific module might be useful.

Finally, in other addiction-related disorders, the notion of harm reduction is part of evidence-based treatment (Marlatt et al., 2011). For example, rather than an abstinence-only approach to reduce problematic alcohol use on campuses, harm reduction might include offering safe rides home to reduce drunk driving accidents, or educating students about how to track and limit their alcohol consumption. This could be expanded to our understanding of problematic gaming in the context of ADHD. If an emerging adult with ADHD were to implement time limits on their gaming or add a gaming 'curfew,' especially with the support of a trusted person to keep them accountable, they might be able to engage in gaming in a way that is less likely to result in impairment. These strategies would fit well in existing ADHD treatment packages.

Limitations and future directions

The findings reported herein should be understood in the context of the limitations of this study. First, the sample was a mostly white group of 4-year college students, which limits the generalizability of findings. Next, all measures in this study were self-report, which have several inherent limitations, including over- and under-reporting for various reasons (e.g., self-handicapping, positive illusory bias, cry for help). Thus, future studies would benefit from the inclusion of a more diverse sample, and collateral report of symptoms and impairment to help corroborate the self-report (e.g., Sibley et al., 2012; Martel et al., 2017). In addition, only symptoms were measured in the current study; not diagnoses. That is, ADHD and problematic gaming symptoms were examined continuously, and therefore we cannot make conclusions about individuals with an ADHD or possible IGD diagnosis. Indeed, we used a relatively high-functioning community sample. Therefore, the findings and conclusions should be interpreted with caution. Finally, it was beyond the scope of this paper to include symptoms of other mental health issues that might lead a person to game in a problematic way, such as symptoms of depression and anxiety. It will be interesting to examine the relation between problematic gaming and these internalizing symptoms in the future. Nonetheless, this study informs our understanding of the interplay between ADHD symptoms, problematic gaming, sex, and impairment, and future studies may be able to build on this foundation.

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Data Availability The data used for the current study are available from the corresponding author on reasonable request.

Declarations

Statements and declarations Compliance with Ethical Standards All procedures followed were in accordance with the ethical standards of the responsible committee on human experimental (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5).

Informed consent was obtained from all participants included in the study.

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