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Concurrent gaming disorder/internet gaming disorder and electronic nicotine delivery systems
dependency in emerging adults

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Abstract

A growing proportion of young adults report regularly playing video games and using electronic nicotine delivery systems (ENDS). Although video gaming is often normative and adaptive, excessive gaming is associated with adverse health outcomes and dependency, as seen in gaming disorder/internet gaming disorder (GD/IGD). Possible additive detrimental effects of ENDS use on the physical outcomes of GD/IGD lends particular concern to these concurrent behaviors. The present study explored group differences in concurrent ENDS and GD/IGD dependency by demographic factors, including age, sex, gender, sexual orientation, racial identity, relationship status, and year in school. The interaction effect of symptoms of attention-deficit hyperactivity disorder (ADHD) on the association between ENDS dependency and GD/IGD was also examined. Lastly, group differences in ADHD symptoms for individuals who endorse 1) neither GD/IGD or ENDS dependency 2) either GD/IGD or ENDS dependency, or 3) both GD/IGD and ENDS dependency was explored. Data were collected in a large, multi-university sample of college students ($N = 1,054$). Higher symptoms of GD/IGD were positively associated with greater symptoms of ENDS dependency. Men and individuals with significant symptoms of ADHD were at an increased risk of concurrent GD/IGD and ENDS dependency. These results may be used to identify demographic and psychological associations linked to these comorbidities, ultimately informing future prevention strategies.

Keywords: ENDS, nicotine, gaming disorder, addiction, gender, ADHD

Introduction

Worldwide, nearly two billion people are estimated to play video games (Newzoo, 2020). Potential for harm from excessive video game play is a growing concern, with prevalence estimates suggesting that between 1%-10% of the population play excessively (Forsyth & Malone, 2019). To better classify harm, gaming disorder (GD) has recently been added to the ICD-11, and internet gaming disorder (IGD) is listed as a “Condition for Further Study” in section 3 of the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5; WHO, 2019; APA, 2013). Research has found extensive similarities between symptoms of GD/IGD and symptoms of other addictive disorders, including the presence of cravings, compulsion, and inability to stop despite adverse consequences (Saunders et al., 2017).

Video gaming occurs most frequently in adolescents and emerging adults. Over half of adolescents video game daily, and the average video-gaming adolescent plays roughly 1.5 hours per day (Forsyth & Malone, 2019). College students are at risk for developing GD/IGD, potentially because of the increased freedom, internet access, and removal of prior social support that may accompany the transition to college (Reynolds et al., 2019). Video gaming also disproportionately occurs in males: approximately 75% of boys game daily, whereas only 35% of girls game daily (Forsyth & Malone, 2019). Among adults, men spend greater amounts of time gaming per week, play for longer sessions, and spend more money on gaming than their female counterparts (Wang et al., 2014).

Although video gaming is primarily normative and adaptive, excessive video gaming is associated with financial strain, social and occupational difficulties, and the development and/or exacerbation of other mental illnesses (Alonso et al., 2011). These effects extend to adverse behavioral health events, including sleep deprivation, day-night reversal, dehydration,

malnutrition, obesity, seizures, pressure sores, and a sedentary lifestyle (Kohorst et al., 2018; Peracchia & Curcio, 2018). For college students, excessive video gaming is associated with lower college GPA, lower rates of matriculation, and difficulty maintaining social relationships (Özçetin et al., 2019).

Video gaming also is associated with increased use of substances, including marijuana, caffeine, and nicotine as found in cigarettes, or e-cigarettes (electronic nicotine delivery systems; ENDS; Van Rooij et al., 2014). Although cigarette use among adolescents is in overall decline, ENDS use rates have grown dramatically in recent years (Drope et al., 2018; Federal Trade Commission, 2018). Among college students, self-reported vaping within the past month increased from 6% to 16% from 2017 to 2018 (Federal Trade Commission, 2018). Despite the common belief that ENDS are a safer alternative to traditional cigarettes, ingredients within ENDS are known contributors to chronic obstructive pulmonary disease, cardiovascular disease, and cancer, in addition to nicotine's association with sleep disruption, anxiety, and nutritional deficiencies (Occupational Safety and Health Administration, 2020; Substance Abuse and Mental Health Services Administration, 2017; US Department of Health and Human Services, 2014). ENDS' harmful consequences may intensify the health risks associated with GD/IGD, especially in connection to sleep, nutrition, and mental health.

Given the potential risk for negative psychological and physical outcomes of concurrent GD/IGD and ENDS dependency, there is also a need to understand possible explanations for this relation. There is extensive overlap between typical video gamers' demographic characteristics and typical nicotine users, including being young, male, and not having a college degree (Von der Heiden et al., 2019). As such, demographic correlates may help explain co-occurring nicotine use and video gaming. However, to our knowledge, no research has specifically examined

demographic risk factors for concurrent GD/IGD and ENDS dependency. Psychological predispositions may further explain concurrent GD/IGD and ENDS dependency. Specifically, attention-deficit hyperactive disorder (ADHD) symptoms, such as impulsivity, inattention, and sensation-seeking, may serve as possible third or explanatory variables of the association between both dependencies (Alonso et al., 2011; Matthews et al., 2019). Individuals with ADHD may be particularly receptive to the addictive, highly rewarding stimuli found in video games due to disinhibition and novelty-seeking (Luman et al., 2010; Mathews et al., 2019). Similarly, the poor self-regulation and self-control associated with impulsivity may lead to increased difficulty with directing appropriate amounts of time and resources to video gaming (Matthews et al., 2019). Delay discounting, which refers to the tendency to prefer larger, later rewards over smaller, more immediate rewards, is often disrupted in individuals with elevated impulsivity and ADHD, increasing susceptibility to the reinforcement schedules present in video games and developing GD/IGD (Antrop et al., 2000).

Individuals with more symptoms of ADHD are more likely to use nicotine, to begin smoking younger, and are twice as likely to develop nicotine dependence (Bilgi et al., 2017; Gray et al., 2010; Laucht et al., 2007). The nicotine in cigarettes and ENDS may be used to self-medicate since the stimulant properties of nicotine emulate prescription stimulants approved to treat ADHD (Bilgi et al., 2017). After smoking initiation, reducing nicotine consumption is particularly challenging for individuals with heightened impulsivity and inattention, potentially due to the re-emergence or worsening of psychological dysfunction (Bidwell et al., 2017). Therefore, a shared vulnerability exists for individuals with ADHD to develop both GD/IGD and nicotine dependency.

The present study explored group differences in concurrent ENDS and GD/IGD

dependency by demographic factors, including age, sex, gender, sexual orientation, racial identity, relationship status, and year in school. The interaction effect of ADHD on the association between ENDS dependency and GD/IGD was also examined. It was hypothesized that self-reported ADHD symptoms would moderate the strength of the association between GD/IGD and ENDS dependency. Lastly, differences in ADHD symptoms for individuals who endorse 1) neither GD/IGD or ENDS dependency 2) either GD/IGD or ENDS dependency, or 3) both GD/IGD and ENDS dependency were analyzed. It was hypothesized that symptoms of ADHD would be highest for individuals with concurrent dependencies.

Materials and Methods

Participants

Participants ($N = 1,054$) were college students ages 18-24 ($M = 19.25$) recruited as part of a multi-university study examining psychological and social predictors of health-related behaviors in emerging adults. A convenience sample of seven small and mid-sized universities located across the continental U.S. participated in this study. The sample was 73% female and 27% male. The ethnic makeup of the sample was predominantly White (74.9%), followed by Black (8.8%), Asian (6.7%), and Multiracial (4.7%). Each University's Institutional Review Board approved all study procedures. Participants received an online link directing them to the online survey and had to agree to the informed consent online prior to completing a battery of self-report questionnaires. Participants were compensated for their time with either course research credit or an entrance in a drawing for a gift card.

Measures

ENDS dependency was assessed through the E-cigarette Dependence Scale (EDS; Morean et al., 2018). The EDS is a 4-item questionnaire assessing the frequency of symptoms of

ENDS dependence. Response options range from 0 (*never*) to 4 (*almost always*), resulting in summed scores ranging from 0-16. The EDS has demonstrated excellent internal consistency ($\alpha = .86$) and reliability (Morean et al., 2018). In the current study, the reliability of the EDS was high ($\alpha = .92$). EDS scores > 0 are indicative of symptoms of ENDS dependence (Morean et al., 2018).

Symptoms of GD/IGD were determined through the Video Game Dependency Scale (abbreviated as CSAS for the German version ‘Computerspielabhängigkeitsskala;’ Rehbein et al., 2015). The CSAS was adapted from a previous instrument (KFN-CSAS-II) to assess the nine DSM-5 criteria used to diagnose other addictions. Each DSM-5 criterion was assessed through two items, resulting in an 18-item scale. Participants are classified as having probable GD/IGD if they strongly endorsed 5 of the 9 DSM-5 criteria (Rehbein, et al., 2015). In the current study, the reliability of the CSAS was high ($\alpha = .94$).

ADHD was measured through the Adult ADHD Self-Report Scale, Fifth Edition (ASRS-5; Kessler et al., 2002; Kessler et al., 2005). The ASRS-5 is a self-report questionnaire assessing for the frequency of experienced ADHD symptoms over the past 6 months per DSM-5 criteria (Kessler et al., 2002). The ASRS-5 is commonly administered in both clinical (Reyes et al., 2019) and non-clinical (Kessler et al., 2007; Herrmann et al., 2009) samples to assess for symptoms of ADHD. The ASRS-5 demonstrates high classification accuracy as evidenced through behavioral and neural correlates of ADHD. The ASRS-5 evidences high internal consistency ($\alpha = .88$) and high intraclass correlation coefficients between scales (.84; Adler et al., 2006). In the current study, the reliability of the ASRS-5 was high ($\alpha = .92$).

Participants were asked to self-report their demographic information in the following

domains: age, sex, sexual orientation, racial identity, relationship status, and year in school.

Statistical Analyses

The IBM SPSS Statistics version 26 was used for conducting statistical analyses. Listwise deletion and full information maximum likelihood (FIML) were used to address missing data. Pearson correlations were used to examine the association between GD/IGD symptoms and symptoms of ENDS dependence. χ^2 tests evaluated group differences on relationship status, sex, sexual orientation, racial identity, and year in school, based on the presence of GD/IGD and ENDS dependency. T-tests were used to examine group differences for age based on GD/IGD and ENDS dependency.

To further explore the relation between GD/IGD and ENDS dependency, conditional process modeling was used to test for moderation using the PROCESS macro in SPSS. Specifically, it was evaluated whether symptoms of ADHD strengthened the relation between the GD/IGD and ENDS dependency scales. The moderating effects of ADHD were calculated using hierarchical linear regressions wherein the main effects were presented in the first step, and interaction effects in subsequent steps. Significant covariates, as indicated by the results of χ^2 and t-tests, were included. Bonferroni adjusted alpha levels were applied post hoc to account for multiple tests. The variables were centered to avoid issues of multicollinearity and utilized 10,000 samples for bootstrapping.

Finally, multivariate analysis of covariance (MANCOVA) analyses were conducted to explore if significant differences existed on measures of ADHD symptoms for individuals who endorsed 1) neither GD/IGD or ENDS dependency 2) either GD/IGD or ENDS dependency, or 3) both GD/IGD and ENDS dependency. Significant covariates were included in the model.

Results

Nearly one-fifth (19.4%; $n = 203$) of the sample endorsed ENDS dependency, 4.7% ($n = 50$) endorsed significant symptoms of GD/IGD, and 1.9% ($n = 20$) endorsed both GD/IGD and ENDS dependency. More symptoms of GD/IGD were significantly associated with greater ENDS dependency, $r(1,072) = .174, p < .001$. A χ^2 test of independence determined that men were significantly more likely than women to demonstrate symptoms of concurrent GD/IGD and ENDS dependency, $\chi^2(1, N = 1,054) = 17.69, p < .001$. Sexual orientation, racial identity, relationship status, age, and year in school did not significantly differ by status of GD/IGD and ENDS dependency (see Table 1).

The moderating effect of ADHD symptoms (i.e., impulsivity, inattention, and sensation-seeking) on the relation between GD/IGD and ENDS dependency was significant, $\Delta R^2 = .067, F(1, 1036) = 24.75, p < .001$. Also included in this model was sex (male = reference category). As hypothesized, the strength of the relation between GD/IGD and ENDS dependency was stronger when participants endorsed more severe ADHD symptoms.

The MANCOVA indicated that self-reported ADHD symptoms significantly differed among individuals who endorsed neither GD/IGD or ENDS dependency ($M = 44.77, SD = 0.39$), either GD/IGD or ENDS dependency ($M = 49.82, SD = 0.78$) and both GD/IGD and ENDS dependency ($M = 58.90, SD = 2.56$). Sex (male = reference category) was included as a covariate in this model. As hypothesized, ADHD symptoms were significantly higher for individuals who endorsed both GD/IGD and ENDS dependency compared to individuals reporting either GD/IGD or ENDS dependency. Furthermore, individuals reporting either GD/IGD or ENDS dependency had higher mean ADHD symptom scores than individuals reporting neither GD/IGD or ENDS dependency.

Discussion

Emerging adulthood is a critical period for the development of high risk and addictive behaviors that have meaningful long-term implications (Reynolds et al., 2019). The high prevalence of both GD/IGD and ENDS use within emerging adults merits further investigation into these behaviors within a college population (Drope et al., 2018; Newzoo, 2020). Due to the limited research on concurrent ENDS dependency and GD/IGD, the present study explored group differences in concurrent ENDS and GD/IGD dependency by demographic factors, including age, sex, gender, sexual orientation, racial identity, relationship status, and year in school. The interaction effect of ADHD symptoms on the association between ENDS dependency and GD/IGD also was examined. Lastly, group differences for ADHD symptoms between individuals who endorsed 1) neither GD/IGD or ENDS dependency 2) either GD/IGD or ENDS dependency, or 3) both GD/IGD and ENDS dependency were explored.

The findings suggest that both GD/IGD and ENDS dependency is a significant problem for college students, with 4.7% endorsing GD/IGD. This is comparable to past research which found that between 2.7%-5.2% of 4-year college students met criteria for GD/IGD (Borges et al., 2021). The present study also found that 19.4% of the sample endorsed ENDS dependency and 1.9% of the sample endorsed concurrent GD/IGD and ENDS dependency. The proportion of participants endorsing ENDS dependency is similar to previous estimations of ENDS use among 4-year college students at 15% (Schulenberg et al., 2019). When these rates are extrapolated to the entirety of college students in the U.S., approximately 300,000 students would be expected to report concurrent GD/IGD and ENDS dependency, a small but significant percentage when compared to 3,980,000 college students meeting criteria for alcohol use disorder (McFarland et al., 2018).

There also was a significant association between ENDS dependency and GD/IGD, with higher symptoms of ENDS dependency correlating with greater symptoms of GD/IGD. Since substance and behavioral dependencies are associated with negative outcomes such as financial strain, occupational problems, and social difficulties, the high rates of college students experiencing GD/IGD and ENDS dependency merits concern and further examination (Kohorst et al., 2018; Peracchia & Curcio, 2018). Men were more likely than women to experience concurrent GD/IGD and ENDS dependency, supporting prior literature that more men use video games and use ENDS (Von der Heiden et al., 2019; Wang et al., 2014). Future research should examine protective factors for the onset of ENDS dependency and GD/IGD for men, including the role of impulse control and behavioral inhibition.

In addition, ADHD symptomology moderated the relation between ENDS dependency and GD/IGD. As such, the relation between GD/IGD and ENDS dependency is strengthened through the third variable of symptoms of ADHD. These results are supported by prior research findings that core symptoms of ADHD, such as impulsivity and sensation seeking, are risk factors for many behavioral health concerns, including engagement in risky sexual behaviors, medication nonadherence, and behavioral and substance addictions (Notzon et al., 2020; Reynolds et al., 2019). Future research should examine the impact of early prevention efforts for adolescents with ADHD to mitigate later development of these risky behaviors. Further, it may be clinically useful to assess for excessive video gaming and nicotine use when treating individuals with ADHD to identify potential behavioral health needs.

Finally, symptoms of ADHD were highest among individuals reporting concurrent dependencies. These findings further support the critical relation of ADHD to problematic and high-risk behavior. Prior literature has established that elevated impulsivity and sensation-

seeking tends to differ among individuals prone to high-risk behaviors, supporting the present findings (Bakhshani, 2014). However, whether these differences exist due to the impact of ADHD symptoms on the initiation of video gaming and ENDS use or increased difficulty with self-management after beginning these behaviors remains unknown. Future research should explore GD/IGD and ENDS dependency's chronological development in relation to the onset of ADHD symptoms.

Limitations

These results should be considered with certain limitations in mind. All participants were college students, which may limit generalizability to other populations and age ranges. The overrepresentation of women in the sample (73.2%) may be a limitation of the current study, particularly since men are at disproportionately high risk for ENDS dependency and GD/IGD. Furthermore, current college students may not be representative of individuals experiencing severe symptoms of addiction. Future research should also examine a more diverse sample with a broader array of ethnicities, ages, and gender identities. Questionnaires used to assess for symptoms of ADHD, GD/IGD, and ENDS dependency were self-report and point only to probable diagnoses that were not confirmed with "gold standard" semi-structured interviews. Future research should include validated diagnostic assessments of these constructs. Finally, this study utilized a cross-sectional design which does not provide insight into the causal relation between ENDS dependency, GD/IGD, and symptoms of ADHD. Future studies using a longitudinal design may offer clarity regarding causation.

Conclusions

Despite these limitations, this study provides novel insight into the co-occurrence of ENDS dependency and GD/IGD. The study population has many strengths, including sampling

across seven different universities across the United States. Ultimately, there is ample evidence that ENDS dependency and GD/IGD are prevalent on college campuses, particularly in men. Furthermore, the relation between ENDS dependency and GD/IGD may be explained, in part, by the presence of ADHD symptoms. Future research examining the onset, progression, and possible need for treatment of concurrent GD/IGD and ENDS dependency is warranted.

PRE-PRINT

Declarations and Compliance with Ethical Standards

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Each of the 7 participating Universities' Institutional Review Board approved the study.

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

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Table 1*Demographic Characteristics of GD/IGD and ENDS Dependency*

Characteristic	Present	Absent	t-test/chi-square test
Age ($M \pm SD$)	19.6 \pm 1.5	19.3 \pm 1.3	t (1054) = -1.04
Sex (%)			(1, n = 1054) = 17.69**
Male	70.0%	27.3%	
Female	30.0%	72.7%	
Race (%)			(1, n = 1054) = 9.57
African American/Black	10.0%	8.9%	
Alaska Native/Pacific Islander	0%	0.6%	
Asian	10.0%	6.9%	
Middle Eastern	0%	0.9%	
White	55.0%	74.2%	
Other	5.0%	3.2%	
Multiracial	20%	5.2%	
Year in School (%)			(1, n = 1054) = 3.65
Freshman	50.0%	48.3%	
Sophomore	10.0%	24.7%	
Junior	20.0%	15.7%	
Senior	15.0%	9.6%	
Fifth year and beyond	5.0%	1.8%	
Sexual Orientation (%)			(1, n = 1074) = 1.36
Heterosexual	95.0%	87%	
Homosexual	0%	2.7%	
Bisexual	5%	7.8%	
Asexual	0%	0.8%	
Other	0%	1.7%	
Relationship Status (%)			(1, n = 1054) = 0.58
Single	60.0%	66.4%	
In a long-term dating relationship	40.0%	32.8%	
Married	0%	0.8%	

Note. * $p < .05$, ** $p < .001$. Present: GD/IGD and ENDS dependent. Absent: does not endorse both GD/IGD and ENDS dependency.